STUDIES ON POWDERY MILDEWS OF SOME ECONOMICALLY IMPORTANT CROPS

ABSTRACT

THESIS SUBMITTED TO THE
ALIGARH MUSLIM UNIVERSITY, ALIGARH
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IN

Botany

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ABSTRACT

Powdery mildews on different members of compositae and Umbelliferae have been taking heavy toll of the crops every year. There has been contradictory reports about the identification of the powdery mildews attacking these crops which has actually led to paucity of information of various aspects of pathogenecity and control of the disease.

In the present studies Erysiphe cichoracearum has been identified as the causal organism of powdery mildew of different members of Compositae and Erysiphe heraclei on different members of Umbelliferae studied. There has been variation in the pathogenecity of E. cichoracearum from non-composit hosts to members of Compositae which might be due to natural variants. All the plants belonging to Umbelliferae have been found to be susceptible to E. heraclei excepting Carum copticum.

The optimum temperature for germination of conidia of E. cichoracearum differed to that of E. heraclei; for the former optimum being 17 - 20° and for the later 22 - 25°C. On the other hand, relative humidity of 95 - 100 percent was found optimum to germination of conidia of both E. cichoracearum and

E. heraclei. It appears that the temperature played a decisive role in the development of the powdery mildews both on Compositae and Umbelliferae. Studies on the effect of different stresses on plants (Lagenaria leucantha & Cucumis sativus) such as infection of roots with root-knot nematodes, soil moisture levels and N K fertilizers showed that when plants were under stress, then development of root-knot was adversely affected.

The effect on powdery mildew has been however variable. The severity of powdery mildew increased in plants inoculated with root-knot nematode. The powdery mildew development was also favoured in autoclaved soil. On the other hand, the severity of powdery mildew decreased when powdery mildew plants were subjected to high/low moisture or fertilizer stresses (without N and 2 N K). The morphometric values of the females of root-knot nematode was high under those conditions which favoured the development of root-knot nematode. On the basis of the available literature the findings on relationship of stresses on powdery mildew and root-knot development appear to be new.

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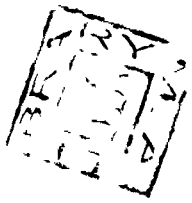

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Dated: April 28,1986

This is to certify that Ms Shobha Mital has worked in this Department as a Research Scholar under my supervision and guidance. Her work on the "Studies on powdery mildews of some economically important crops" is upto-date and original. She is allowed to submit her thesis for the consideration of the award of the degree of Doctor of Philosophy.

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AFFECTIONATELY DEDICATED

TO

MY PARENTS

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Shobha Mital

Shobha Mital

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C H A P T E R - I .

INTRODUCTION

Compositae being the largest family of the Angiosperms with more than 900 genera and 20,000 species and Umbelliferae with more than 200 genera and 2900 species are cosmopoliton in distribution in every type of climate. The chief centres of the distribution are found in North temperate regions however, in tropics the plants are found where lattitude replaces the altitude or during winter where temperature remains low.

Members of the family Compositae are of fairly great economic value with plants of extremely ornamental and of medicinal value. Sunflower is a rich source of fatty and edible oils. The cake left after the extraction of oil is used as high protein supplement for live-stock especially for dairy cows and poultry. The stalks of the inflorescence rich in cellulose contents are used in the manufacture of paper and plastics. Similarly members of the family Umbelliferae are of great economic importance. The seeds of some are used as condiments, and of others are of great medicinal importance. Carrots form a very good source of carbohydrates, vitamins and minerals and especially vitamins A and D.

Almost all the members of family Compositae and Umbelliferae, specially sunflower and carrots are not free from the diseases. Powdery mildew which is one of the most important disease takes a heavy toll of these crops. Unfortunately, systematic studies on the powdery mildews of sunflower and carrots are lacking, despite the importance of the crop and the losses done by them.

Considerable work has been carried out on the cucurbit powdery mildew both in India and elsewhere (Vasudeva, 1960; Jhooty, 1967; Khan et al. 1970,71; Mathur et al., 1971; Kapoor, 1967; Nour, 1957; Clare, 1958; Kable and Ballantyne, 1963; Blumer, 1933, 1967). Cucurbits are also good hosts for root-knot nematode, Meloidogyne spp. Despite interesting work on cucurbit powdery mildews, nothing is known about the incidence of the powdery mildews when cucurbit plants are subjected to different kinds of stresses such as infection in roots, with root-knot nematode, fertilizer and moisture stresses etc.

In view of the above facts, it was considered desirable to study the following:-

1. To survey the incidence and severity of powdery mildew on different composit and umbelliferous crops.

2. Identification of the causal organism of powdery mildew.

3. **Effect of different relative humidity and temperatures** on the germination of conidia of the powdery mildew of members of Compositae, caused by, Erysiphe cichoracearum DC. and of Umbelliferae caused by Erysiphe heraclei DC.

4. Effect of different temperatures and relative humidity on the development of powdery mildew on detached leaves.

5. Host range of powdery mildew of Compositae and Umbelliferae within the members of the respective families and outside the families.

6. Susceptibility of different composits to root-knot nematode Meloidogyne incognita (Kofoid and White, 1919) Chitwood, 1949.

7. The effect of root-knot nematode, M. incognita-

   (a) On the development of powdery mildew of composit and cucurbits (Erysiphe cichoracearum DC. & Sphaerotheca fuliginea (Schlecht) Poll.) and the morphometrics of the root-knot nematode.

   (b) on the rhizosphere mycoflora of Lagenaria leucantha (Duch) Rusby

8. **Effect of different moisture levels on the development of root-knot nematode, M. incognita and powdery mildew, S. fuliginea on different cucurbits.**

9. **Effect of N & K fertilizers, on the development of powdery mildew (S. fuliginea) on Lagenaria leucantha when infected with root-knot nematode, M. incognita.**

CHAPTER - II

REVIEW OF LITERATURE

The family Erysiphaceae contains many serious plant pathogens commonly known as "Powdery mildews", which cause tremendous losses to a wide variety of crops and at times resulting in complete loss of the crops. The very name of the disease indicated that it produces enormous number of conidia on the surface of the host forming a white powdery mass. These fungi attack both the stem and young leaves; the latter becoming chlorotic and killed in extreme cases. Fruits on such infected plants either do not set or if they are formed, they ripen prematurely with poor flavour and sugar contents.

Considerable amount of damage due to powdery mildews has been reported on large number of crops and at times it exceeded 20 percent. Jagger (1926); Milbrath (1927) and McKeen (1954) reported heavy losses in yield of Muskmelon due to powdery mildew, while Szembel (1930) and Tafradzhiiski (1959) reported it very destructive to cucumber. Last (1957) pointed out that powdery mildew caused 68 percent reduction in the yield of barley. A reduction of 33 to 90 percent has been reported in grapes (Arnaud and Arnaud, 1931) and 80 percent in peaches (Fikry, 1936). Heavy losses due to this group of

Fungi have also been reported by Cannon (1962) on potatoes; by Palm (1921), Alexandroff (1927), Minev (1957), Wober (1959) and Cole (1964) on tobacco; Ganguly and Pandotra (1963-64) on mint and by Moore (1956) on pepper. Matta and Garibaldi (1969) reported severe losses to crops of dill in the Albenga region of Italy. Similar losses occured to fennel crops (Noviello, 1961), which is an increasingly essential oil crop in Southern Italy. In India, Uppal et al. (1935) reported severe losses due to powdery mildew on Pea. In case of severe infection, even one picking is not possible against 6-7 pickings from a normal crop. In 1963 Munjal et al. observed that, on the powdery mildew of Pea, the loss was proportional to the disease intensity between the limits, 50-100 percent. Gupta and Dalela (1962) reported that powdery mildew caused 83 percent losses in late sown coriander crops. Similar heavy losses were reported by Srivastava et al. (1971) on these crops with reduction in seed yield and also loss in the colour and seed quality.

IDENTIFICATION OF THE PATHOGEN AND HOST RANGE:

Majority of the powdery mildews, including the species attacking cucurbits, seldom produce perfect stage in nature, therefore criteria other than the perfect stage such as, the colour of the mucelium, presence or absence of fibrosin

bodies and production of germ tube or appressoria like bodies were resorted to for establishing the identify of powdery mildew by various workers (Hirata, 1942; Nour, 1957; Clare, 1958; Kable and Ballantyne, 1963; Zaracovitis, 1965; Blumer, 1967; Kapoor, 1967; Jhooty, 1967; Mathur et al., 1971, 1974).

The powdery mildew of the majority of the members of Compositae has been identified as E. cichoracearum. This is recognised by two spored asci and basally inserted appendages which are much longer than the diameter of the ascocarp. It resembles S. fuliginea in possessing conidia in long chains which has possibly led to the confusion. The main characters taken into consideration was the colour of mycelium but further identification was based on the presence of fibrosin bodies which are present in S. fuliginea and absent in E. cichoracearum. Tarr (1952) and Nour (1957) from Sudan; Clare (1958); Kable and Ballantyne (1963) from U.S.A.; Boerema and Vankesteren (1964) from the Netherlands employing different characters of conidia and mycelia, concluded that S. fuliginea is the causal organism of cucurbit powdery mildew. More recently, Zaracovitis (1965); Goster (1966); Blumer (1967); Kapoor (1967) and Mathur et al. (1971) suggested that the S. fuliginea and E. cichoracearum can be differentiated on the basis of production of forked germ tube in S. fuliginea and appressoria like bodies in E. cichoracearum.

Mckeen et al. (1966), while studying the pathogenicity of E. cichoracearum on H. annuus examined the infected leaves under electron microscope and concluded that the haustoria of the fungus were elongated, ellipsoidal with twisted branches and were bathed in a cavity surrounded by the plasma membrane of the host. Mckeen and Bhattacharya (1968) further observed changes in the constituents of the host cell wall surrounding the infection peg of powdery mildew fungi, as the leaves infected with E. cichoracearum stained intensely with azure dyes, methylene blue and cotton blue.

Salmon (1900) named powdery mildew on Umbelliferous hosts as E. polygoni. Later Nour (1959) preferred the name Erysiphe umbelliferarum because of the shape ofthe conidium is cylindrical. Mathur et al (1974) were also of the views that powdery an umbelliferous hosts is E. umbelliferarum.

However Kapoor (1967) reported E. heraclei DC. on umbelliferous crops and distinguished it from the other species of Erysiphe in having elongate cylindrical conidia and numerous short irregularly branched appendages in the cleistothecia.

Powdery mildew fungi have by and large, wide host range. Salmon (1900) in his "Monograph of the Erysiphaceae" listed about 1500 species as the hosts of powdery mildews. Weiss (1950)

recorded powdery mildews on the 1340 out of 3100 host species shown in U.S.D.A. index of plant diseases. Blumer (1967) observed powdery mildew on 1928 plant species belonging to different families of Angiosperm. According to Hirata (1971), the powdery mildew fungi are the parasites of the angiosperms, especially the dicotyledons. More than 6500 host species belonging to 146 families of dicotyledons make a wide host spectrum.

Neger (1923) reported perfect stage of S. fuliginea on Epilobium montanum (Onagraceae) and Taraxacum officinalis (Compositae) from Germany; while Blumer (1933) observed S. fuliginea on Adenostyles alliariae, Arnica nontana, Bidens cernuus, B. melanocarpus, B. tripartitus, Bellidiastrum michelii, calendula officinalis, Crepis paludosa, C. blattarioides, Erigeren acer, E. candense, Helianthenum canum, H. bulgare, H. grandiflorum, Leontoden hispidusand and Taraxacum officinalis (Compositae); Moore (1947) reported Doronicum spp. as the host of powdery mildew.

Hirata (1966) reported that sunflower had been infected with S. fuliginea in China, France, Japan, Holland, Italy, Yugoslavia and Switzerland.

In India, Jhooty (1965) found sunflower infected with S. fuliginea in Chandigarh. Perfect stage of S. fuliginea

has been reported on Helianthus annuus (Patil, 1964; Patwardhan, 1965 from Maharashtra; Prasada et al., 1968 from Rajasthan) and on Dimorphotheca sinuta (Compositae) by Mathur et al. (1971) from Rajasthan. However, Srivastava and Rawat (1982) reported S. fuliginea on Anaphalis contorta (Asteraceae) from Pauri (Garhwal).

Different powdery mildew fungi have been reported from different parts of the world on different mambers of the family Compositae. For example E. cichoracearum on cineraria (Mac Donald, 1939), on Zinnia from California (Baker and Locke, 1946); S. fuliginea on H. annuus (Nomura, 1974) and E. cichoracearum f. sp. helianthi on Helianthus tuberosus, H. scaberimus and H. annuus (Mitov and Popov, 1979; Triolo,1980 and Ialongo, 1981). Blumer (1967) reported that powdery mildew on Chrysanthemum morifolium (or Ch. indicum) is caused by Oidium Chrysanthemi and he considered it to be the conidial state of E. cichoracearum. Grigalyunaite and Shpokauskene (1981) reported O. chrysanthemi on Chrysanthemum from U.S.S.R.

In India, E. cichoracearum has been reported on H. annuus (Patel et al., 1949; Pavgi and Upadhyay, 1966); on Sweet sultan (Centaurea moschata) and Acroclinium (Helipterum roserum and H. album) by Jain and Singh (1968). Leviellula taurica (Oidiopsis taurica) has been reported on Phlox drummondi (Kamat and Patil, 1948); on Helipterum album

(Jain and Singh, 1968); on H. annuus Var. California L. (Desai et al., 1970); on Tridex procumbens (Mathur et al., 1971) and on Chrysanthemum carinatum and Ch. segetum (Prasada et al., 1971). Deshpande and Dake (1978) reported Oidium spp. on Chrysanthemum carinatum, Cosmos diversifolius and Sonchus oleraceus.

E. polygoni, as such has a very wide host range and this aspect led Blumer (1933) to conclude that it is an aggregate species. In India Uppal and Desai (1933); Arya (1957) and Chona et al. (1960) have reported E. polygoni on Cumin (Cuminum cyminum) and Coriander (Coriandrum sativum) and E. umbelliferarum on Carrot (Daucus carota). E. polygoni on coriander has also been reported in India by Anonymous, (1950), Gupta and Delela (1962) and Srivastava et al. (1971). Vasudeva (1963) reported Cleistothecia of E. polygoni on carrot seeds.

Komirna (1938) recorded E. umbelliferarum f. anethi on funnel (Foeniculum vulgare) from Russia and considered it identical with the powdery mildew on dill (Anethum graveolens). Leveillula taurica has been reported to infect coriander in Sudan (Boughey, 1946) and Pakistan (Khan and Kamal, 1962). Chorin and Patli (1962), however, reported Oidiopsis taurica (L. taurica) on carrots in Israel.

In India L. taurica (O. taurica) has been reported on F. vulgare and Cu. cyminum (Anonymous, 1950); on D. carota (Desai et al., 1970) and on C. sativum (Prasada et al., 1971). Mathur et al. (1974) while making a comparative study of spore morphology of Erysiphe spp. on umbelliferous hosts suggested that powdery mildew fungi of umbelliferous hosts viz. Cuminum cyminum, Coriandrum sativum, Daucus carota, Foeniculum vulgare and Anethum graveolens be placed under E. umbelliferarum. However, Gupta et al. (1982) reported E. heraclei infecting carrots in India.

E. heraclei on carrot, fennel, parsely and parship seed has been reported by Noviello (1961); Boerema et al. (1963); Noble and Richardson (1968) and Ferri (1969). Hirata (1966) reported five umbelliferous crops viz. angelica, celery, dill, funnel and parsely have been found to badly infected with E. heraclei in Japan. Geary and Wall (1976); Abiko (1976) and Ryan et al. (1983) reported E. heraclei on carrots from Norfolk, Japan and Dublin respectively. On the other hand Matta (1962); Abercrombie and Harry (1976) and Wu (1977) reported E. polygoni on carrots. It is clear from the above that despite so many reports the identify of powdery mildew on umbelliferous and composit hosts remainadilemma.

Reed (1908) observed that the cucumber isolates of E. cichoracearum infected sunflower while the isolates from

sunflower, infected cucumber and Squash poorly. Miller and Barrett (1931), on the other hand, showed that forms on cucumber and sunflower did not cross infect each other. Schmitt (1955), while confirming these findings, showed that Zinnia strains of E. cichoracearum had a wider host range than the forms of Inula, Helianthus, Cerianthe, Phlox or cucurbits, Zinnia isolates have been reported to attack Z. elegans, Z. pauciflora, Z. verticillata, H. annuus, Arctium minus, A. nemorosum, Xanthium chinense, X. spinosum, X. strumarium, Mikania scandens, Hieracium alpinum, H. prehanthoides, Inula helenium, Carlina acaulis, Lactuca perennis, Cosmos sp., Scorzonera hispenica and Felicia amelloides of the family Compositae; Salkiglossia sinulata of Solanaceae and Cerianthe major of Boraginaceae. Phlox isolates were restricted to P. drummendi and cultivated perennial Phlox. The cucurbit isolates infected only members of Cucurbitaceae but failed to develop on any other non cucurbit hosts included in the test.

According to Schnathorst et al., (1958) Calendula isolate of E. cichoracearum was pathogenic on Calendula officinalis and Silybum marianum, while Lactuca sativa isolate on C. officinalis, L. sativa, L. serriola, S. marianum and Z. elegans. Isolates from L. serriola, Salinus and Z. elegans infected L. serrida, S. marianum and Z. elegans, while that

from California infected L. serriola and L. morianum. Therefore, the isolates of E. cichoracearum from different hosts and even different localities from the same host differed in their host range. Schnathorst et al. (1958) also reported that lettuce isolates of E. cichoracearum infect both potted and detached leaves of Calendula officinalis; var. doubled mixed; Dahlia variabilis Var. Unwins Dwarf. Hybrids; H. angustifolius; H. annuus; L. serriola; Silybum marianum; Senecio cruentus; Z. elegans Var. Floredales Scarlet and Giant fantary; Delphinium hybridum Var. Giant imperial blue shade.

E. umbelliferarum on the other hand has a narrow host range (Nour, 1959). Daucus carota and Faba bona, which has more or less identical conidia, gave negative results when the conidia from former host were deposited on leaves of latter even at optimum atmospheric conditions. Marras (1961) distinguished three host specialised strains of E. umbelliferarum on carrot, fennel and parsley on the basis of conidial measurements. Abiko (1981) while testing a large number of plants concluded that E. heraclei from carrot infected only carrot. However, isolates of E. heraclei from Chenopodium ambrosioides and Torilis japonica did not infect carrots.

ENVIRONMENT AND POWDERY MILDEW:

The literature pertaining to the effect of different environmental factors on powdery mildew has been reviewed by

Yarwood (1957) and Schnathorst (1965). It was claimed that the development of powdery mildew in general was favoured by warm humid weather (Anonymous, 1946 and 1950); by green house conditions as against out door conditions (Steiner, 1908; Tucker, 1952) and hot dry weather (Wager, 1937). Out of these various environmental factors, temperature and moisture have been reported to have a profound effect on powdery mildews.

The cardinal temperature for germination of conidia of different strains of E. cichoracearum ranged between 5-35°C (Levykh 1940; Deslandes, 1954; Rossouw, 1959; Schnathorst, 1960; Morrison, 1961, 1964; and Tafradzhiiski, 1963), and for infection and growth ranged between 5-32°C (by Levykh, 1940; Deslandes, 1954; Minev, 1957; Rossouw 1957 & 1959 and Schnathorst, 1960). Conidial germination of E. cichoracearum from lettuce was highest at 18°C (Schnathorst, 1960). The cardinal temperature for infection was 6-10°C (minimum), 18°C (optimum) and 27°C (maximum).

Chen and Chen, (1981) observed highest germination of conidia of E. heraclei between 20-32°C.

Moisture is another important factor which influences the germination of conidia, infection and growth of powdery mildews; and formation and maturation of perithecia.

D'Angremond (1924) observed heavy infection of E. cichoracearum on tobacco grown in field of high water level.

Corner (1935) reported that the conidia of E. graminis, Podosphaera lucotricha, S. pannosa and E. cichoracearum succumbed when remained in water for 1-3 hours. However, floating conidia germinated readily after 24 hours and produced upright germ tubes.

Hashioka (1937) found that conidia of S. fuliginea germinated between relative humidity of 15-85 percent. Survival of conidia was for 14 days at 76 to 80 percent relative humidity; for 24 days at 93 to 98 percent; and for 38 days in a saturated atmosphere. Tafradzhiiski (1963) reported that conidia of S. fuliginea germinated best at relative humidity of 94 percent but they failed to germinate in drops of water.

According to Levykh (1940) there was no development of symptoms when tobacco plants inoculated with E. cichoracearum were exposed to 10 percent relative humidity at 18-19°C. However, the typical symptoms developed when the relative humidity was 70-76 percent. According to Deslandes (1954) a relative humidity of 85 percent was optimum for infection and sporulation in powdery mildew. Minev (1957), Schnathorst (1960), Morrison (1961, 1964) and Tafradzhiiski (1963) reported that the germination occurred slightly below the saturation. Optimum relative humidity ranged between 66-68 percent for tobacco strains (Minev, 1957); and 95.6-98.2 percent for lettuce strains (Schnathorst, 1960) and 94 percent for cucurbit strain (Tafradzhiiski, 1963).

Germination of conidia was also observed in calcium chloride chamber at 0.1 percent relative humidity by Morrison (1961, 1964) and Schnathorst (1960). Rossouw (1959), on the other hand, reported the germination of conidia both at 0 percent and 100 percent relative humidity. Corner (1935), Minev (1957) Morrison (1961, 1964) and Tafradzhiiski (1963), reported that free water inhibited the germination of conidia while Deslandes (1954) reported that conidia of lettuce strain of E. cichoracearum were able to germinate in free water. Schnathorst (1960) observed that moisture stress gave highest germination of conidia of lettuce strain of E. cichoracearum. The development of powdery mildew was most affected by temperatures but atmospheric humidity influenced the rapidity and severity of disease development. Highest germination of conidia of L. taurica from Cynara annuum was achieved at 100% relative humidity (Clerk and Ayeruoffei, 1967). At low humidity there was not only a decline in germination but a reduction in mean germ tube length. Morrison (1964) observed that free water on leaf disc surfaces inhibited the germination of conidia of large number of powdery mildew fungi, but high relative humidity favoured the germination.

Nour (1958) studied the effect of different relative humidity on percentage germination of conidia of various powdery mildew fungi. The germination of conidia of E. umbelliferarum from D. carota or Faba bona was invariably very poor. Under

drier conditions no germination was observed. Conidia of S. fuliginea and E. cichoracearum show higher sensitivity to dryness. However, conidia of E. umbelliferarum (which are apparently to very short lived) gave poor germination even at saturation.

Rajderkar (1966) observed that the production of Cleistothecia of E. umbelliferarum on carrot was very high when exposed to low temperature (0.5°C and 9°C) or to alternating wet and dry conditions within the range of 25-27°C, when treated with certain vitamins or 10-25 percent sucrose. Malik et al., (1973) reported that under Aligarh conditions formation of cleistothecia of E. heraclei on D. carota was observed late in the season i.e. during April-May. Chen and Chen (1981) pointed out that the germination of conidia of E. heraclei on carrots occurred at 20 percent relative humidity. The conidia germinate from 20-32°C on 2 percent water agar plate with optimum temperature at 28°C.

It has been claimed that both infection and incidence of powdery mildew were severe under dry rather than under wet climatic conditions (Wager, 1937; Anonymous, 1946; Boughey, 1949; Palti, 1953). D. Angremond (1924); Blumer (1927); Deslandes (1954) and Morrison (1961) reported that high relative humidity favoured the incidence of powdery mildew. Brisley (1926); Beeley

(1932); Moore (1936); Fisher (1938); Bremer (1940) and Parris (1949) were also of the opinion that overhead irrigation favoured the development of powdery mildew. Schnathorst (1959) reported that the growth of mycelium was abnormal, when a film of moisture was present on the surface of the epidermis. Yarwood (1939); Schnathorst (1959) and Morrison (1961), on the other hand, reported that film of free water did not favour the development of the powdery mildew. Salmon (1903), Yossifovitch (1923) and Moseman et al. (1957) observed that free water was essential for the maturation of ascospores. Disease epidemics on artichoke are associated with limited rainfall and decreasing autumn temperatures, cultivars which have almost entire leaf blades and no spine are most resistant than those with lobate leaves (Ciccarone, 1953).

The conidia of powdery mildew fungi have been found to germinate at a wide range of pH but highest germination has been observed at pH 6.6 to 7.0 (Yarwood, 1957).

Childs (1940) observed diurnal cycle of ascospores maturation in certain powdery mildew. Periodic microscopic examination of the sunflower, rose, apple, aster and cucumber infected with E. cichoracearum revealed a more complex diurnal cycle of conidiophore development. Abstriction occured between 6-8 a.m. and then at 2-4 p.m. and formation of the succeeding

crop of conidia occurred between 2-4 p.m. and 6-8 a.m. Highest abstriction of conidia of sunflower powdery mildew occurred between 8.00 a.m. and 2.00 p.m.

The germination of conidia was also influenced by the time of collection of conidia. Yarwood (1936) reported that highest germination of conidia of E. polygoni occurred when the spores were collected in the afternoon. Their germination, however, decreased with the onset of the darkness and the least germination was observed in the early morning. Jhooty (1970), while confirming the above findings, pointed out that such diurnal cycle was absent in S. fuliginea, S. macularis, E. graminis and E. cichoracearum. However, Yarwood (1936) suggested that regular alternation of light and dark periods may be responsible for expression of this phenomenon. Jhooty (1971) was of the view that alternation of light and dark periods may not be the basic cause of this phenomenon, but it certainly influenced the onset of low and high cycle in germination of conidia of E. polygoni.

Different environmental conditions also influenced the production of perithecia (Yarwood, 1957). Bauchheium (1928) and Blumer (1948) reported that low relative humidity favoured the formation of perithecia. Similarly Biolotti (1907) reported that low temperature favoured the development of perithecia in

powdery mildew in general. Cherewick (1944) and Arya and Ghemawat (1954), on the other hand, reported that in E. graminis alternating moderate and low temperatures favoured the formation of perithecia and ascospores. Schnathorst (1959) reported that the formation and maturation of perithecia was also a matter of time rather a cyclic changes in temperature or alternate wetting and drying. He observed the formation of perithecia of E. cichoracearum at 23°C with 300 foot candle illumination in leaf culture in 7 days. Perithecial development was also reported at 13°C with 60 percent relative humidity and 900 foot candle illumination by Schnathorst (1959). These observations led Bessey (1943) and Ainsworth (1950) to conclude that perithecia rarely developed in tropics. , Yarwood (1957) reported that amongst the different climatic factors temperature appeared to be more important for perithecial production. This is however, not true as in large number of powdery mildew fungi perithecial development has been observed in India. Patwardhan (1965) while studying the effect of different factors affecting the development of perithecia in powdery mildew of H. annuus, observed development of perithecia during monsoon on large number of hosts.

According to Yarwood (1938) The Sunflower plants grown in Hoagland solutions minus Boron were severely stunted and

heavily mildewed, while plants grown with 1 and 10 parts per million of boron supplied as boric acid made a normal growth and were much less mildewed.

Severity of mildew is positively correlated with plant vigour and that any soil or other factor which promote plant vigour also favours and development of powdery mildew (Arnaud and Arnaud, 1931; Smith and Blair, 1950).

Trelease and Trelease (1928) and Mansson (1955) found that low nitrogen and high potassium reduced the development of powdery mildew. Cole (1964, 1966), on the other hand, reported plants grown in water culture fortified with all the elements were more susceptible to E. cichoracearum than those grown in which the ratio of Potassium and nitrogen was low. Laibach (1930) and Homma (1937) reported that low nutritive condition of host favoured the development of perithecia.

EFFECT OF STRESS CONDITIONS ON DISEASE DEVELOPMENT

Stress conditions have been found to influence the plant diseases through their effect on pathogen, host susceptibility or on the host pathogen interaction (Schoeneweiss, 1975).

Moisture Stress- Leaphart and Stage (1971) concluded that advance growing conditions, particularly extended drought was instrumental in the origin and severity of pole blight of white pine. Couch & Bloom (1960) and Moore et al. (1963) pointed out that water stresses predisposed kent bluegrass to Sclerolinia homeocoupa (Couch and Bloom, 1960) and Highland bentgrass to Pythium ultimum. There have been many reports of increase in disease intensity when plants were subjected to water stress such as crab apples to Physolospora obtusa (Landis and Hart, 1967), loblolly pines to Fomes annosus (Towers and Stambaugh, 1968), in aspens to Hypoxylon pruinatum (Baga and Smalley, 1967, 1974), in paper mulberry to Fusarium solani (Schreiber and Dochinger, 1967), and European white birch stems to attack by Botryosphaeria dothidea. On the other hand, Filer (1967) found no correlation between bark moisture content and susceptibility of cotton wood stems to Cytospora, Phomopsis and Hypomyces.

A few reports show that excess of water has predisposing effect on disease development. Tinsley (1953) observed that increasing the water supply of plants increased the amount of infection by viruses. Development of root diseases is favoured by excess of soil moisture (Cook,1973). Vascular diseases take serious turn in wet than in dry soil. (Cook, 1973).

Similarly in nematode diseases Wallace (1956) reported that both too high and too low soil moistures were detrimental to nematodes. In the high soil moistures, the soil pores are filled with water providing anaerobiosis and in the low soil moistures, water is practically not available for the nematode development. Rao and Israel (1971) reported that soil moisture range between 20-30 percent was most suitable in Meloidogyne incognita for larval invasion and its development in the host and the egg mass production.

Soil moisture also influenced the hatching of larvae and their viability (Linford, 1941), Dropkin and Martin (1957) observed that soil moisture stress not only caused permanent wilting of plants but also inhibited the infestation of root-knot nematode, Meloidogyne spp.

Nutrient Stress- Considerable work has been done on the effect of NPK on disease susceptibility in large number of diseases (Gaumann, 1950; Yarwood, 1959 and Bollard and Matthews, 1966). Large amounts of nitrogen fertilizers have been found to favour infection while excess of potassium reduces infection. However the effects of excess of phosphorus are variable (Gaumann, 1950 and Yarwood, 1959).

Wingard (1941) has observed that nutritional stresses of the host affects each disease differently. Gaumann (1950) pointed out that nutrient imbalance undoubtedly affects host vigour and might influence defense reactions.

In nematode diseases, too excess of nitrogen has been found to favour the development of nematode disease (Shands and Crittenden, 1957; Mc-clure and Viglierchio, 1966), while excess of phosphorus and potassium resulted in the poor disease development (Birat, 1963). Oteifa (1951, 1953); Shands and Crittenden (1957); Bird (1960); Marks and Sayre (1964) and Haque et al. (1972, 1974) reported that excess of K favoured the development of disease caused by root knot nematode, while Yein et al. (1977) reported that inorganic fertilizers had no material effect on root knot nematode infesting moong. Oteifa (1953) reported that the rate of development of M. incognita on roots of lima beans increased with the addition of pottassium in the nutrient solution, while Marks and Sayre (1964) observed that in case of cucumber, rate of development decreased at low levels of potassium but was accelerated at high levels probably due to the fact that excess of K facilitated the entry of larvae of root knot nematode into roots (Shands and Crittenden 1957). Bird (1960) reported that nitrogen deficiency favoured M. incognita. Similarly,

Haque et al. (1972, 1974); Ismail and Saxena (1976, 1980) and Pant et al. (1983) reported increased root knot development on tomato and other crops with increase in dose of K fertilizer.

Other Stresses - No attempts has been made here to review the entire literature on the effect of other stresses on disease development, but evidences do indicate that temperature, transplantation, defoliation, light-stresses influence the development of diseases (Chamberlain, 1972; Levitt, 1972; Schoeneweiss, 1973; Stephen and Hill, 1971; Gaumann, 1950; Yarwood, 1959 and Reed, 1968). Toxic substances such as weed killers and pesticides cause adverse effect on plant growth and indirectly on the development of infectious diseases. Exposure to atmospheric pollutants decreased parasitic diseases. Wounding (Gaumann, 1950 and Yarwood, 1959) reduced host vigour due to attack by parasitic nematodes (Powell, 1963).

No work has been done on the biotic stress on development of diseases. When roots of plants are infected with nematode, the plants are weakened and are therefore under biotic stress. Nothing is known as to how is the development of infectious disease in the aerial parts of such plants is influenced. Although, considerable work has been done on the interaction of nematode and fungus when both the organisms infect roots in the same niche but this aspect remained untouched.

The literature on the nematode-fungus interaction is reviewed by Powell (1963, 1971) and Pitcher (1965).

NEMATODE-FUNGUS COMPLEXES

In nematode-fungus interaction plants are under stress when infected with one pathogen and may facilititate the development of other pathogens. Atkinsen (1892) was among the first to notice this association when he observed that infection by root-knot nematodes (Meloidogyne spp.) increased the severity of Fusarium wilt in cotton. Jenkins and coursen (1957) induced wilting in Fusarium wilt resistant tomato variety only when root knot nematodes were present along with fungal inoculum. Later Minton and Minton (1963) reported M. incognita acrita and F. oxysporum f. vasinfectum in cotton. They noted that in nematode infected roots, the Xylem is exposed to fungus attack. The root-knot Fusarium wilt interaction in tobacco has received similar analysis (Melendez and Powell, 1967). Similarly, Porter and Powell (1967) showed that root-knot nematode predisposed tobacco plants to Fusarium wilt infection. The root knot infection appeared to affect the physiology of the plant, the fungus infection and the development of the wilt symptoms. A disease complex involving M. incognita

and Black shank fungus Phytopthora parasitica Var. nicotianae (wilt disease) in tobacco has been reported Powell and Nusbaum (1960). Another disease complex in tobacco with involving P. parasitica Var. nicotianae and M. javanica has been reported by Miller (1968).

Migratory ectoparasitic nematodes may enhance the severity of certain fungus root rots. Chrysanthemum roots inoculated with Belonolaimus longicaudatus and Pythium aphanidermatum developed symptoms of Pythium root rot earlier and more extensively than those inoculated with the fungus alone (Littrell and Johnson, 1969). Kushner and Crittenden (1967) reported that decay in alfalfa roots by F. roseum or F. oxysporum is increased when M. incognita acrita occurs with the fungal pathogen.

Melendez and Powell (1967) reported that Pythium or Rhizoctonia if added to tobacco plants which have been previously infected by M. incognita, were capable of invading the roots and causing extensive decay. On the other hand, little damage results if the fungus and nematode pathogens are applied simultaneously and virtually no decay occurs resulting from the fungus alone.

Powell et al. (1971) tested tobacco cultivar in combined inoculations with M. incognita and species of the

soil inhabiting fungi Pythium, Curvularia, Botrytis, Aspergillus, Penicillium and Trichoderma. Roots showed symptoms of necrosis when subjected to M. incognita in combination with any one of the fungi. Necrosis was especially severe in treatments in which nematodes preceded the fungi by several weeks. None of the fungi induced disease unless M. incognita was present. These observations stress the importance of disease complexes in root break down, and emphasize the dominant role of M. incognita as a predisposing agent.

Van Gundy and Tsao (1963) reported that citrus nematode Tylenchulus semipenetrans interacts with F. solani to reduce citrus seedling growth, and the effect of the pathogen combination is noticeably greater than that of either pathogen alone. Cotton seedlings grown in soil infested with M. arenarea, M. hapla or M. incognita are susceptible to R. solani longer than those grown in the absence of nematodes (Brodie and Cooper, 1964).

Fusarium wilt of Peas, caused by F. oxysporium f. pisi is influenced markedly by both M. incognita and M. acrita. The nematodes enhanced wilt severity (Davis, 1963; Davis and Jenkins, 1963). Ross (1965) reported cyst nematodes Heterodera glycines and fungus complex on soyabean and stated that the cyst nematodes were more effective in predisposing plants to Fusarium wilt than was M. incognita. In tomatoes,

both the stunt nematode, Tylenchorhynchus capitatus and M. incognita increase incidence of verticillium wilt (Overman and Jones, 1970). Sindhu and Webster (1977) reported that root knot nematode (M. incognita) may transform a genetically resistant host plant of tomato in to one that is susceptible to the wilt fungus (F. oxysporum). Similar observations were made by Moormen et al. (1980) in a tobacco cultivar resistant to Fusarium wilt. Pandey (1984) observed that M. incognita along and in combination with Pythium ultimum and R. solani reduced the growth of sugarbeat seedlings and the effect was additive when two or more pathogens were put together.

FUNGUS EFFECT ON NEMATODE POPULATION - One of the most obvious facts emerging from much of the research on nematode fungus disease complexes is that the fungus component of an interaction often influences the nematode population. (Davis and Jenkins (1963). They reported higher populations of the stunt nematode Tylenchorhynchus claytoni on pea roots infected with Fusarium oxysporium f. pisi than on noninfected plants. Infection by Plasmodiophora brassicae, drastically influences development of M. incognita acrita in cabbage roots (Ryeder and Crittenden, 1965). In plants infected by both pathogens,

giant cells on which nematode feed are invaded by the fungus and disrupts feeding, so nematode fail to develop to maturity. Littrell and Johnson (1969) observed that population of M. incognita is significantly reduced by the presence of Pythium aphanidermatum in roots of chrysanthemum, but reproduction of nematodes is not affected.

Ketudat (1969) reported that the ratio of males to females of a cyst nematode, Heterodera rostochiensis, is increased in tomato if either Rhizoctonia solani or Verticillium albo-atrum is present. Conroy et al. (1972) reported that population of root lesion nematode, Pratylenchus penetrans on tomato seedlings was low when plants were inoculated with both nematodes and fungus V. albo-atrum than with nematode alone.

Jacobsen et al. (1979) observed that M. hapla increased the severity of verticillium wilt in potato, but the nematode population was higher in root system of plants infected with the fungus than on plants infected with the nematode alone.

Pandey (1984) reported that population of the nematode, M. incognita was low in sugarbeet whenever the inoculation of plant with nematode was preceded by the fungus, Pythium ultimum and/or Rhizoctonia solani. Maximum number of galls was recorded on plants inoculated either with nematode alone or nematode followed by fungus.

It is clear from the above review that no systematic work has been carried out on the powdery mildews of members of two important families of angiosperms i.e. Compositae and Umbelliferae. Although some work has been done on the cucurbit powdery mildews both in India and elsewhere, but nothing is known as to the development when cucurbit plants are subjected to stresses such as moisture, nutritions and infection with root knot nematode in roots, with the aim in view the present investigations were undertaken.

C H A P T E R - III

MATERIALS AND METHODS

SURVEY:

Survey for the incidence of powdery mildews was made from different localities at Aligarh where members of compositae and Umbelliferae were grown. There were frequent visits to assess the severity and prevalence of the disease during their growth periods.

The severity of powdery mildew was graded as under -

No infection (-) = No visible disease symptoms
Mild infection (+) = Pustules few, small in size and scattered.
Moderate infection(++) = Pustules many, larger in size, tending to coalesce.
Severe infection (+++) = Big pustules covering almost the entire leaf area.

MAINTENANCE OF CULTURE OF POWDERY MILDEW AND IDENTIFICATION OF THE CAUSAL ORGANISM

For identification of the pathogen, leaves of plants infected with powdery mildew were brought to the laboratory in polythene bags. In order to have inoculum for further studies,

seedlings of the respective hosts in the cotyledonous stage or at 3-4 leaf stage, grown in autoclaved soil contained in 25cm. clay pots were inoculated. For inoculation, technique of dry dusting conidia of the powdery mildew was used (Schmitt, 1955). The inoculated plants were kept in separate glass house chambers at 17-22°C in order to avoid mixing of the inoculum. The inoculum which developed within 5-7 days of inoculation was used in the studies reported herewith.

In the absence of cleistothecia, mycelial and conidial characters were examined for the identification of the powdery mildew. These characters included colour of the mycelium in older pustules (Rodigin, 1936 and Yarwood, 1957); shape of conidia (Alcorn, 1968); presence and absence of fibrosin bodies (Homma, 1937; clare, 1958, 1964; Kable et al. 1963; and Jhooty, 1967) and type of germ tube (Hirata, 1942, 1955; Kable et al. 1963 and Zaracovitis, 1965) and Conidial measurements (Bouwens, 1924, 1927).

For determining the size, about 250 conidia were measured for each of the different powdery mildews and the average range of size was determined. For the presence and absence of fibrosin bodies, conidia were mounted in 3% aqueous solution of KoH as suggested by Kable and Ballantyne (1963).

For studying the type of germ tube, conidia were dusted over dry clean glass slides placed on glass triangles in a petridish containing double distilled water. Later, these were transferred in an incubator running at 17-22°C. After 24 hours, conidia were stained in cotton blue and mounted in lactophenol for observations. Infected materials of D. carota bearing cleistothecia were stored for the detailed study of characters which help in ascertaining the identity. The cleistothecia were stained in cotton blue and mounted in lactophenol. The number of asci per cleistothecium and number of ascospores per ascus were counted. The size of cleistothecia, asci and ascospores was also determined.

HOST RANGE AND VARIETAL RESISTANCE - For host range studies, eight cultivated composits viz. Chrysanthemum carinatum Linn, Calendula officinalis Linn, Cosmos sulphunus cav., Cineraria sp., Dahlia variabilis Desf., Zinnia elegans Jacq., Helianthus annuus Linn., Aster sp.; two wild composits viz. Xanthium strumarium Linn. and Sonchus oleraceus Linn. grown in 25 cm clay pots containing autoclaved soil were inoculated with three isolates of E. cichoracearum obtainedbfrom X. strumarium, H..annuus and D. variabilis and two isolates from cucurbits viz. Coccinia cordifolia (Linn.) Cogn. and Benincasa hispida (Thunb.) Cogn. in glass house as well as in the field.

Six cultivated plants of the family Umbelliferae viz. Daucus carota Linn, Coriandrum sativum Linn., Foeniculum vulgare Mill., Cuminum cyminum Linn., Carum copticum Linn., and Anethum graveolens were grown in autoclaved soil and inoculated with three isolates of E. heraclei obtained from D. carota, C. sativum and A. graveolens in the glass house as well as in the field. These hosts were also tested against the isolates of E. polygoni obtained from Pisum sativum Linn., Cassia oxidantalis Linn., and Chenopodium ambrosoides Linn.

Plants inoculated with different isolates were transferred to glass house at 18 to 22°C. For field studies, inoculated plants were transferred with entire soil to the pits earlier dugged at a distance of 8 - 12 ft. This was done to avoid injuries to the roots. Temperature in field ranged in between 20 to 25°C. at the time the tests were made. For each host-parasite combination there were five replicates. Uninoculated plants served as control. Inoculated plants were regularly examined for the appearance of the disease. Observations were made after twenty day of inoculation. Host response was categorised as under -

Resistant(R) - Mildew failed to appear.

Susceptible(S) - Mildew appear.

For studying the varietal response different cultivars of H. annuus viz. Miniature japanese, Chrysanthemum flower mixed, Bronze hybrid, Sungold dwarf; of Z. elegans viz. persian carpet, Lilliput mixed, California giant mixed and linearies; the seedlings of Dahlia sp. viz. Large flowered mixed, Super giant mixed Decorative mixed and Unwins hybrid mixed were inoculated with different isolates of E. cichoracearum from composits; the seedlings of D. carota viz. Pusa kesar, Tender sweet, Danvers half longs and Nantes early half long with different isolates of E. heraclei from umbelliferaous host.

Observations as to disease intensity were made daily for two to three weeks, after inoculations. Throughout the studies the perithecial production was also examined. Since in these tests more precise observations were modified as follows: (Wheelar, 1969):-

Grade	Description	Infection Rating
Highly resistant	Plants completely free from infection.	0
Resistant	Mycelium developing in small patches disappearing later or at best covering 1-25% leaf area.	1

Moderatily resistant	Mycelium developing both an leaves and stem covering 26-50% leaf area.	2
Susceptible	Many small colonies appearing later coalesceing and covering 50-75% leaf area. Mycelium developing on stem as well.	3
Highly susceptible	Entire plant covered uniformly by mildew	4

EFFECT OF TEMPERATURE ON GERMINATION OF CONIDIA

For determining the effect of temperature on germination of conidia, freshly formed conidia were dusted over the dry clean glass slides, kept in incubation chamber. The assembly of the incubation chamber was transferred to temperature cabinets running at -5, 5, 10, 17, 20, 25 and 30°C. After 8, 12, 24, 36, 48, 60 and 72 hours of incubation, Slides were examined for germination of conidia and the percentage germination was determined.

EFFECT OF RELATIVE HUMIDITY ON GERMINATION OF CONIDIA

Super-saturated solutions of following salts were prepared to maintain the different relative humidities (Hand book of Chemistry and Physics, 1957).

Super saturated solutions of	Relative humidity (%) at 20°C
Sodium nitrate	66
Sodium acetate	78
Ammonium sulphate	81
Zinc sulphate	90
Sodium hydrogen phosphate	95
Double distilled water	100

These solutions were transferred to lower chambers of small dessicators which served as humidity chambers. Freshly developed conidia almost of the same age were dusted uniformly over the clean cover glasses with the help of glass rod (Nair, Sadasivan and Ellingboe, 1962). The entire assembly was kept at 20°C. After 8, 12, 36, 48, 60 and 72 hours of incubation, the number of conidia that had germinated and that failed to germinate were counted and the percentage germination of conidia was calculated. The data so obtained were subjected to statistical analysis.

EFFECT OF DIFFERENT TEMPERATURES ON THE DEVELOPMENT OF POWDERY MILDEW ON DETECHED LEAVES AT THREE DIFFERENT RELATIVE HUMIDITIES.

The studies on effect of different temperature at three different relative humidities on the development of powdery mildew were done on deteched leaves of 3 varieties of H. annuus and two of Z. elegans respectively. For this purpose plastic petriplates were taken. In the centre of petriplates a hole of 5 mm. was made through which petiole could passed. Through this hole a glass tube was fixed with the help of parafin wax. In the petriplates super-saturated solution of the chemicals (Listed on page 39) was kept. Each petriplate contain supersaturated solution of one chemical. The petriplate was made air-tight and placed over a beaker containing water. Detached leaves were placed inside the petriplates over the glass slides. Conidia of E. cichoracearum (obtained from H. annuus & Z. elegans) were dusted over the leaves for inoculation. The petiole of the leaf was passed through the glass tube to be dipped in water. One set of petriplates was kept at room temperature (± 20°C), another in glass house (± 25°C). Three sets were placed in incubator at temperature of 5°C, 10°C and 32°C respectively. Observations were made 10 days after inoculations for the appearance of powdery mildew.

COMMON HOST TEST - Powdery mildew disease of cucurbits seem to be largely caused either by Sphaerotheca fuliginea or Erysiphe cichoracearum. For the test of common host, the seedlings of Cucumis sativus were raised in 25 cm claypots containing autoclaved soil. Plants were inoculated with conidia of E. cichoracearum and S. fuliginea obtained from Coccinia cordifolia and Lagenaria leucantha respectively. The treatments were given in five following sets -

(A) Plants were inoculated with E. cichoracearum only.

(B) Plants were inoculated with S. fuliginea only.

(C) E. cichoracearum and S. fuliginea both inoculated on different leaves of the same plant.

(D) Half portion of a leaf inoculated with E. cichoracearum and half portion with S. fuliginea.

(E) Control

All the sets were kept in glass house (temp. 22-25°C). Observations were made after 15 days of inoculations, for the appearance of mildew and after 60 days of inoculation for the production of pertithecia, if any.

INTERACTION OF POWDERY MILDEW AND NEMATODES

Powdery mildew development was also determined when the plants were under stress of one kind or the other. The composit

and cucurbit plants were subjected to different stresses such as plants infected with root knot nematode, treated with different concentrations of fertilizers and grown at different moisture levels. The development of powdery mildew was observed as a result of stresses.

MAINTENANCE OF CULTURE OF THE NEMATODE

In order to raise single egg mass population of *M. incognita*, seedlings of tomato raised in sterilized mixture of sand and soil (1 : 3) were inoculated with the larvae hatched from single egg mass of nematode obtained from infected tomato roots. Large number of such inoculations were made to ensure that infection had taken place and lastly one plant showing infection was selected as the culture of nematode. The pots were transferred in glass house to avoid contamination.

Throughout the studies, inoculation of plants with the nematode was done by pipetting the suspension containing 1000±10 larvae of the nematode in the holes made in the soil around the root zone and then sealing them.

SUSCEPTIBILITY OF DIFFERENT COMPOSIT PLANTS TO ROOT-KNOT NEMATODE AND THEIR EFFECT ON MORPHOMETRICS OF FEMALES OF MELOIDOGYNE INCOGNITA

Seedlings of different composit plants (Listed in table 19) were raised in sterilized mixture of soil and sand (3:1), when in 3-4 leaf stage, these were inoculated with freshly hatched 1000 larvae of nematode obtained from the culture mentioned as above. Observations were made after 50 days of inoculation with regard to the growth of plants, root knot index and population of the nematode. The females of nematode were dissected from roots and killed and fixed for studying the morphometrics of the nematode.

DEVELOPMENT OF POWDERY MILDEW ON PLANTS INFECTED WITH ROOT-KNOT NEMATODE.

The seeds of composit viz Dahlia variabilis and two cucurbits viz. Lagenaria leucantha and cucumis sativus, after having them surface sterilized with $Hgcl_2$ and raised with sterilized water were sown in sterilized mixture of soil and sand (3:1). The seedlings when in 3-4 leaf stage were inoculated

with 1000 freshly hatched larvae of nematode. For inoculation with powderymmildew, plants were inoculated by dry dusting the conidia of Sphaerotheca fuliginea (In case of L. leucantha and C. sativus) and Erysiphe cichoracearum (In case of D. variabilis) obtained from L. leucantha and H. annuus from the culture maintainednin glass house. The treatments given were (1) plants inoculated with nematode alone (2) plants inoculated with fungus alone (3) simultaneously inoculation of fungus and nematode (4) inoculation of fungus after 15 days of nematode inoculation. Each treatment was replicated thrice. The plants were kept in glass house to avoid contamination. The development of powdery mildew was recorded regularly and the final observation was taken after 20 days and that of root-knot after 50 days of inoculation. Observations were made regard to the growth of plant, knot knot index, population of nematode and the development of powdery mildew. The females of nematode were dissected from roots and killed and fixed for studying the morphometrics of the nematode. The size of conidia were also measured on fungus alone and fungus nematode infected plants.

RHIZOSPHERE OF POWDERY MILDEW, NEMATODE AND BOTH WITH POWDERY MILDEW AND NEMATODE INFECTED PLANTS.

Seeds of L. leucantha and C. sativus were surface sterilized and sown in autoclaved soil. Seedlings when in three leaf stage

were transferred both in unsterilized soil (naturally infested field soil) and autoclaved soil and inoculated with 1000 larvae of M. incognita per 500 gm soil/plant and later with powdery mildew, S. fuliginea. Some of the seedlings were exclusively inoculated with S. fuliginea or the nematode. Equal number of seedlings were left uninoculated for control. After 45 days after the nematode inoculation, appearance and severity of powdery mildew, growth of plants, population of nematodes and the rhizosphere fungi were determined. The extent of variation in different morphometrics characters were also determined.

For the isolation of the rhizosphere fungi Warcups (1950) plate method was used. The soil around the roots of plants were brought to the laboratory in sterile containers. The plants were shaken to remove superfluous soil from the root system. The soil adhering to the roots was collected and a little amount of soil with the help of sterilized flattened tip of a needle was transferred to petridishes containing 10 ml of sterilized melted and cooled peptone dextrose agar medium (Parkinson,1957) with the following combination.

Agar	20 gm.
KH_2PO_4	1.0 gm
$Mgso_4.7H2O$	0.5 gm

Dextrose	-	100 gm.
Distilled water	-	1000 ml.
Rose Bengal	-	1: 30,000
Streptomycin or	-	3 µg/ml or
Aureomycin		2 µg/ml

(Martin, 1950) (Johnson, 1957)

The petriplates were rotated before solidification of agar in order to disperse the soil particles evenly. The plates were then incubated at 18°C. The fungi developed after one week of the incubation were examined and identified. The frequency of fungi was calculated as follows:-

$$\frac{\text{Number of plates containing a particular fungus}}{\text{Total plates poured}} \times 100$$

In order to determine the population of fungi the average weight of the soil held on a flattened tip of needle was determined. The number of colonies developed in all plates was counted and this figures was transformed to the number of colonies per gram of soil.

EFFECT OF DIFFERENT SOIL MOISTURE LEVELS

Seedlings of different cucurbits were transplanted in soil and sand (3:1) mixture contained in 4 inches clay pots of known weight and maintained at different soil moisture levels. There were following treatments:-

1. Inoculation with root knot nematode.
2. Inoculation with root knot nematode and the powdery mildew fungi.

The seedlings were inoculated with 1000 second stage larvae of root knot nematode obtained from single egg mass culture. The soil moisture content was maintained on the basis of oven dry soil so as to have 10, 20, 30, 40 and 50 percent soil moistures. The pots were covered with polythene sheets to check plants the loss of water due to evaporation. The required amount of water was added each day to compensate the loss of water, if any.

After 50 days of inoculation plants were uprooted and the intensity was determined.

EFFECT OF FERTILIZERS

Since there has been a tendency to use indiscriminately inorganic fertilizers for growing crops, it was considered

desirable to study development of powdery mildew in soil fertilizer with N.K. fertilizers and to determine the extent of variation in root-knot nematode morphometrics in bi-pathogenic conditions. The fertilizers were added as follows:-

Nitrogen as Urea - 2.2 gm/kg. of soil

Potassium as Potassium nitrate - 2.6 gm/kg. of soil

The treatments were as under:

Nitrogen alone

Potassium alone

Nitrogen and Potassium (Sub optimal dose)

Nitrogen and Potassium (Optimal dose)

Nitrogen and Potassium (Double dose)

Seedlings of cucurbits Lagenaria leucantha and Cucumis sativus raised in steam sterilized soil were transferred in soil containing the above mentioned doses of fertilizers. The plants were inoculated with root knot nematode alone, powdery mildew alone and with nematode and powdery mildew together. Uninoculated plants served as control. There were three replicates of each treatments. After 50 days of nematode inoculation, the growth of plant and number of nematodes were determined and nematodes were killed and fixed for morphometric studies.

PREPARATION OF SLIDES

Roots of infected plants were chopped in to small pieces, and were killed and fixed by adding warm cotton blue in lactophenol. The root pieces were kept in lactophenol till they were cleared. The females of nematode were dissected and mounted in lactophenol in cavity slides (Southey, 1970).

RECORD OF DATA

After 50 days, the plants were uprooted and length, fresh and dry weight of plants were record. The root knot index was rated as follows:-

0 = no infection
1 = Formation of 1-20 galls.
2 = Formation of 21-40 galls.
3 = Formation of 41-60 galls
4 = Formation of 61-80 galls
5 = Formation of 81-100 galls.

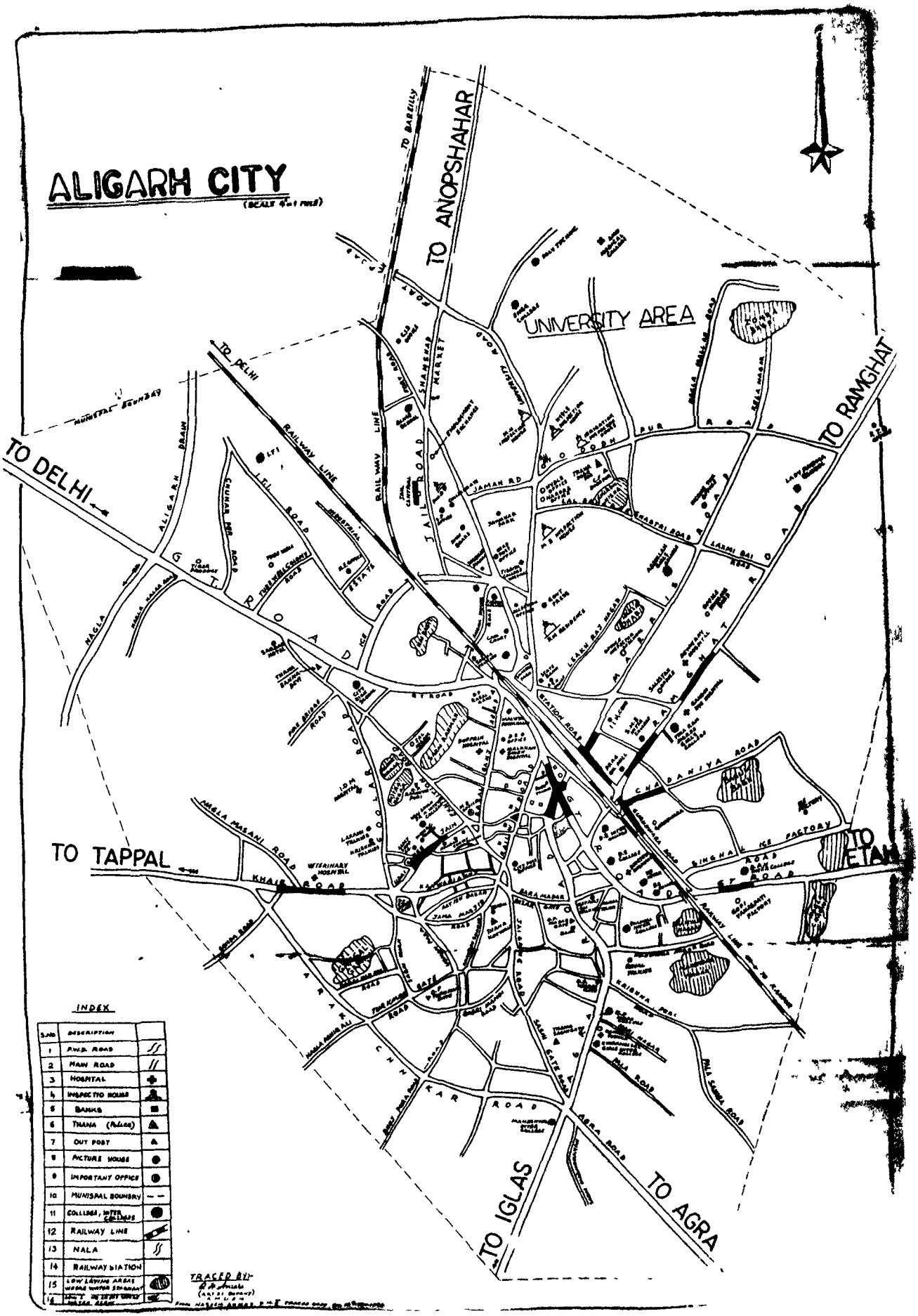
The field population of nematode both in roots and soil were determined. Isolation of nematodes from soil were made by

using Cobb's sieving and decantation method and from roots by Blender method (1953). Five grams roots from each treatment were blended in a waring blender which were operated for 30 seconds. The nematode suspension obtained from 250 gm of soil or 5 gm of roots were kept on tissue paper mounted on coarse sieve. The whole assembly was kept in an enamel tray. After 24 hours the aliquotes were then transferred in to a beaker and 5 ml from this were counted under stereoscopic microscope. Three such countings were made, and the figure thus obtained was multiplied to obtain the values per 250 gm soil/5 gm of roots.

The following characters of Meloidogyne females were taken in to consideration for studying morphometrics.

1. Body length
2. Body width
3. Neck length
4. Neck width
5. Median Bulb length
6. Median Bulb width

The data so obtained were subjected to statistical analysis.


ALIGARH CITY
(SCALE 4 INCH = 1 MILE)
TO ANOPSHAHAR
TO BAREILLY
UNIVERSITY AREA
TO DELHI
TO RAMGHAT
TO TAPPAL
TO AGRA
TO IGLAS
TO ETAH
RAILWAY LINE
G T ROAD
STATION ROAD
INDEX
1 P.W.D. ROAD
2 MAIN ROAD
3 HOSPITAL
4 INSPECTION HOUSE
5 BANKS
6 THANA (POLICE)
7 OUT POST
8 PICTURE HOUSE
9 IMPORTANT OFFICE
10 MUNICIPAL BOUNDRY
11 COLLEGE, INTER COLLEGE
12 RAILWAY LINE
13 NALA
14 RAILWAY STATION
15 LOW LAYING AREAS
16

C H A P T E R - IV

EXPERIMENTAL RESULTS

SURVEY

A survey, to determine the incidence and severity of powdery mildew on different members of the family compositae and Umbelliferae was carried out at different localities in Aligarh. Results presented in table 1 show that different composits viz - Helianthus annuus, Zinnia elegans, Dahlia variabilis, Cosmos sulphunus, Calendula officinalis , Chrysanthemum carinatum and cineraria sp. and two wild composits viz - Xanthium strumarium and Sonchus oleraceus were found to attacked by powdery mildew to a varying degree.

Similarly, different umbelliferous crops viz - Daucus carota, Coriandrum sativum, Anethum graveolens, Foeniculum vulgare, Cuminum cyminum and Carum copticum were also found attacked by powdery mildews with varying degree of infection at different places (Table - 2). The detailed results are given below:

A. Members of compositae (Table - 1)

University Campus - During January to March severe infection was noticed on H. annuus and X. strumarium, moderate infection

on Z. elegans, D. variabilis and S. oleraceus while mild infection was found on C. sulphunus and Cineraria sp.. Mild infection was observed on Z. elegans and X. strumarium during April - June, H. annuus and S. oleraceus remained free from infection. These were the only crops found in field out of those selected for study. During October to December D. variabilis, Co. sulphunus and Cineraria sp., however, remained free from infection. Mild infection was found on H. annuus, Z. elegans and S. oleraceus and moderate only on X. strumarium. There was no disease development on Calendula officinalis and Chrysanthemum carinatum during any of the growing seasons.

Fort Area - During January to March mild infection was observed on Co. sulphunus, moderate on D. variabilis and severe on H. annuus, Z. elegans, S. oleraceus and X. strumarium. During April to June, only mild infection was observed on X. strumarium and H. annuus, Z. elegans, and S. oleraceus remained free from infection. During October to December no infection was observed on D. variabilis and Co. sulphunus, while mild infection on H. annuus and Z. elegans and moderate on S. oleraceus and X. strumarium, on the other hand Cineraria sp., Cl. officinalis and Ch. carinatum remained free from infection.

Dodhpur Area - During January to March severe infection was found on X. strumarium, moderate on H. annuus, Z. elegans and S. oleraceus and mild on D. variabilis. However, during April to June infection was mild on Z. elegans, S. oleraceus and X. strumarium; X. strumarium was also found moderately infected during October to December, whereas mild infection was observed on S. oleraceus ; H. annuus, Z. elegans and D. variabilis remained free from infection.

Gular Road Area - During January to March moderate infection was noticed on H. annuus, Z. elegans and S. oleraceus and severe on X. strumarium. There was no infection of powdery mildew on H. annuus, Z. elegans and S. oleraceus and mild on X. strumarium during April to June. During October to December moderate infection on X. strumarium, mild on S. oleraceus whereas, H. annuus and Z. elegans remained free from infection.

There was no disease development on Cl. officinalis and Ch. carinatum during any of these growing seasons at any localities.

B. Members of Umbelliferae (Table 2)

University Campus Severe infection was noticed on D. carota, C. sativum and F. vulgare and moderate on A. graveolens during February to May; Mild infection on D. carota and C. sativum

in January. Disease was not found on Cu. cyminum and . . Ca. copticum in any of the period of survey.

Fort Area - During February to May severe infection was noticed on D. carota, C. sativum and moderate on F. vulgare and A. graveolens. In January, moderate infection was found only on D. carota and mild on C. sativum; whereas, F. vulgare and A. graveolens remained free from infection.

Doodhpur Area - D. carota, C. sativum and F. vulgare were moderately infected during February to May. During other periods disease was not found on any of the crops in the field.

Agra Road Area - During February to May severe infection was noticed on D. carota; moderate on Cu. cyminum and F. vulgare; and mild on A. graveolens. Mild infection was noticed on D. carota and C. sativum in January. During January there was no development of powdery mildew on A. graveolens and F. vulgare. Similarly there was no infection on Cu. cyminum in any of the growing seasons surveyed when the crop was in the field.

Delhi Road Area - Moderate infection was noticed on D. carota, C. sativum and F. vulgare during February to May. During October to January there was no disease development on any of the hosts surveyed.

Table - 1

Incidence and severity of powdery mildew on different composits at in different localities at Aligarh during January to March, April to June and October to December.

Hosts	Severity											
	University Campus			Fort Area			Dodhpur Area			Gular Road Area		
	Jan-March	April-June	Oct-Dec.	Jan-March	April-June	Oct-Dec.	Jan-March	April-June	Oct.-Dec.	Jan-March	April-June	Oct.-Dec.
Helianthus annuus	+++	-	+	+++	-	+	++	-	-	++	-	-
Zennia elegans	++	+	+	+++	-	+	++	+	-	++	-	-
Dahlia variabilis	++	ab	-	++	ab	-	+	ab	-	ab	ab	ab
Sonchus oleraceus	++	-	+	+++	-	++	++	+	+	++	-	+
Xanthium strumarium	+++	+	++	+++	+	++	+++	+	++	+++	+	++
Cosmos sulphunus	+	ab	-	+	ab	-	-	ab	ab	ab	ab	ab
Cineraria spp.	+	ab	-	-	ab	-	ab	ab	ab	ab	ab	ab
Calendula officinalis	-	ab	-	-	ab	-	-	ab	ab	ab	ab	ab
Chrysanthemum carinatum	-	ab	-	-	ab	-	ab	ab	ab	ab	ab	ab

+++ = Severe Infection
++ = Moderate Infection
+ = Mild Infection
- = No Infection
ab = Host plant not found.

Table - 2

Incidence and severity of powdery mildew on different umbelliferous plants at different localities at Aligarh during February to May, June to September and October to January.

Hosts	Severity														
	University campus			Fort Area			Dodhpur Area			Agra Road			Delhi Road Area		
	Feb-May	June-Sept.	Oct.-Jan	Feb-May	June-Sept.	Oct-Jan	Feb-May	June-Sept	Oct-Jan	Feb-May	June-Sept.	Oct-Jan	Feb-May	June-Sept.	Oct-Jan
Daucus carota	+++	ab	+*	+++	ab	++*	++	ab	-	+++	ab	+*	++	ab	-
Coriandrum sativum	+++	ab	+*	+++	-	+*	++	-	-	++	-	+*	++	-	-
Anethum graveolens	++	ab	-	++	ab	-	ab	ab	ab	+	ab	-	ab	ab	ab
Foeniculum vulgare	+++	ab	-	++	ab	-	++	ab	-	++	ab	-	++	ab	-
Cuminum cyminum	-	ab	-	-	ab	-	ab	ab	ab	-	ab	-	-	ab	-
Carum copticum	-	ab	-	-	ab	-	ab	ab	ab	ab	ab	ab	ab	ab	ab

+++ = Severe Infection
++ = Moderate Infection
+ = Mild Infection
- = No Infection
ab = Host plant not found.
* = Infection occurred only in January.

Fig. 1 (A) Effect of powdery mildew on growth of plant, Helianthus annuus.

(B) Leaves and stem of H. annuus infected with powdery mildew.

FIG. 1 A.

FIG. 1 B.

It is clear from the survey at different places that disease was not found on Cu. cyminum and Ca. copticum in Aligarh.

IDENTITY OF THE CAUSAL ORGANISM

(A) On hosts of the family compositae: It is clear from table 3 (Fig. 2) that the colour of the mycelium of H. annuus; X. strumarium; Co. sulphunus; D. variabilis; S. oleraceus and Z. elegans infected with powdery mildew was greyish-white. The conidia were elliptical in shape with some rounded (Fig.3), measuring 21.0-35.0 x 10.5 - 17.5 µm; 21.0 - 31.5 x 10.5 -19.0 µm; 19.0-31.5 x 10.5 - 17.5 µm; 21.0-35.0 x 10.5-17.5 µm; 17.5-30.0 x 10.5-17.5 µm and 21.0-31.5 x 10.5-17.5 µm respectively. The conidia on all the hosts ranged from 17.5-35.0 x 10.5-19.0 µm. Fibrosin bodies were absent in conidia. On germination the conidia produced germ tube with simple appressoria (Fig. 4). These characters shows that the powdery mildew on the above hosts was Erysiphe cichoracearum.

B- On hosts of the fam. Umbelliferae - The powdery mildew on D. carota; C. sativum; A. graveolens and F. vulgare showed that the colour of mycelium was greyish-white, the conidia

Table - 3

Mycelial and conidial characters of powdery mildew obtained from six composits and four Umbelliferous plants.

Hosts	Colour of the mycellium	Presence/ absence of Fibrosin bodies	Measurement of conidia µm	Shape of conidia	Structure of germ tube
COMPOSITS					
Helianthus annuus	GW	FA	21.0-35.0x10.5-17.5	E	S
Xanthium strumarium	GW	FA	21.0-31.5x10.5-19.0	E+R	S
Cosmos sulphunus	GW	FA	19.0-31.5x10.5-17.5	E+R	S
Dahlia variabilis	GW	FA	21.0-35.0x10.5-17.5	E	S
Sonchus oleraceus	GW	FA	17.5-30.0x10.5-17.5	E+R	S
Zinnia elegans	GW	FA	21.0-31.5x10.5-17.5	E	S
UMBELLIFEROUS HOSTS					
Daucus carota	GW	FA	24.5-42.0x10.5-14.0	C	CA
Coriandrum sativum	GW	FA	24.5-38.5x10.5-15.5	C	CA
Anethum graveolens	GW	FA	21.0-35.0x10.5-14.0	C	CA
Foeniculum vulgare	GW	FA	21.0-38.5x10.5-14.0	C	CA

GW = Greyish white
FA = Fibrosin bodies absent
E = Elliptical shape
E+R = Shape Elliptical, some are rounded
C = Cylindrical shape
S = Straight germ tube with simple appressoria
CA = Germ tube with complex appressoria.

Fig. 2. (A) Leaves of Helianthus annuus infected with powdery mildew.

(B) Leaves of Dahlia variabilis infected with ~~pow~~ powdery mildew.

(C) Leaves of Xanthium stumarium infected with powdery mildew.

FIG. 2 A

FIG. 2 B

FIG. 2C

Fig.3 (A) Conidia of *Erysiphe cichoracearum* from *Dahlia variabilis*.

(B) Close-up

(C) Close-up under oil-immersian.

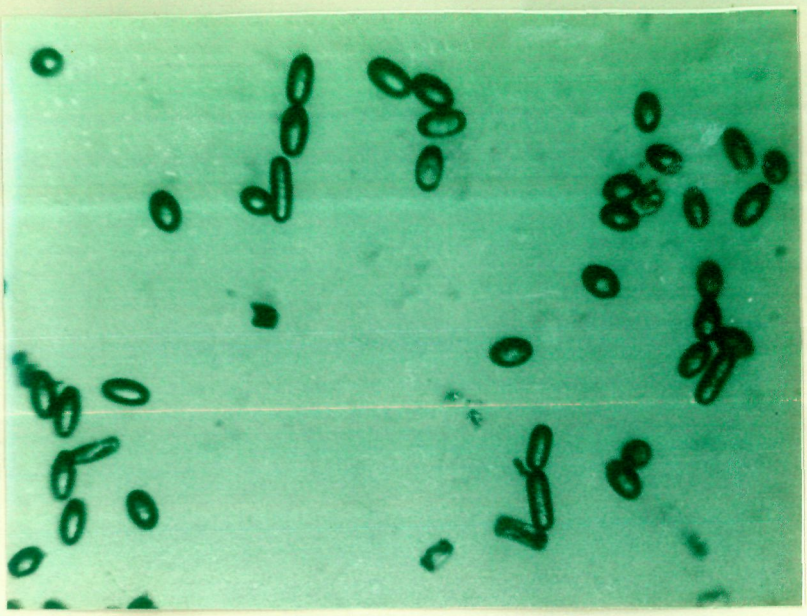


FIG. 3 A

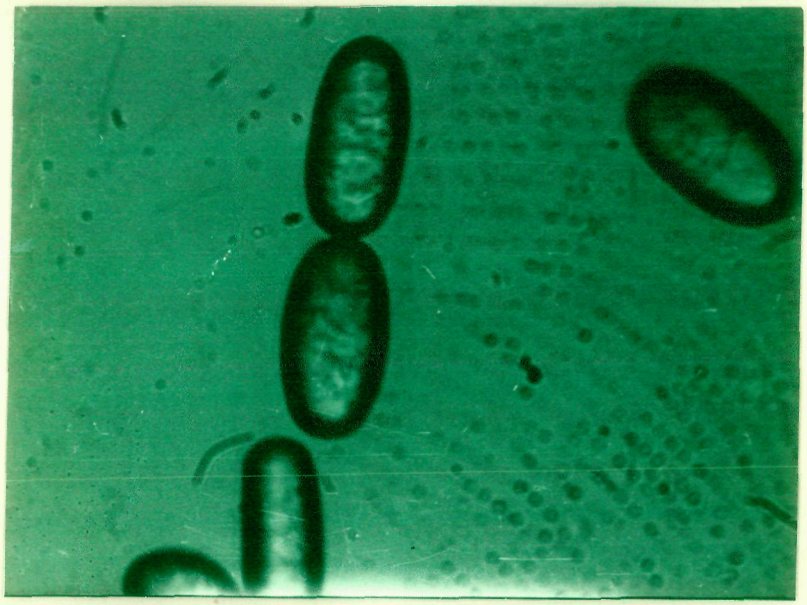


FIG. 3 B

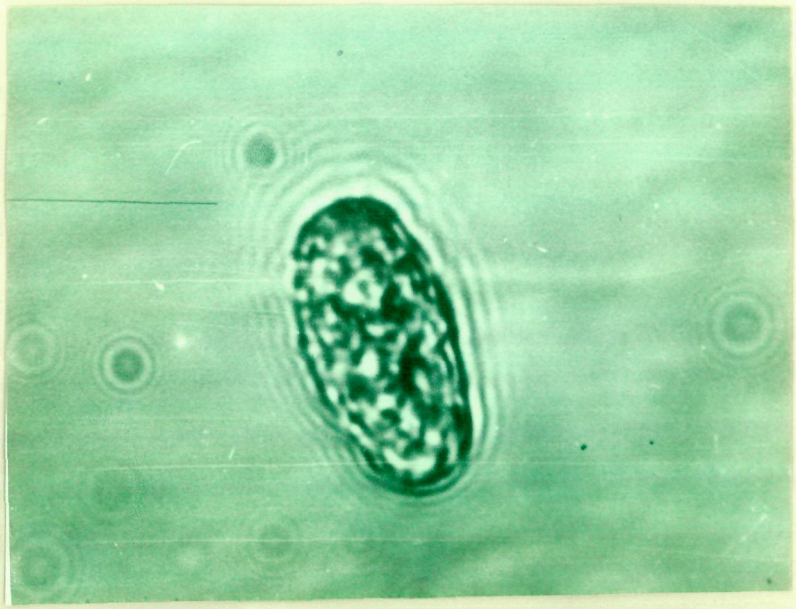


FIG. 3 C

Fig. 4. (A) Germinating conidia of *Erysiphe cichoracearum*

(B) A Germinating conidium of *E. cichoracearum* (close-up).

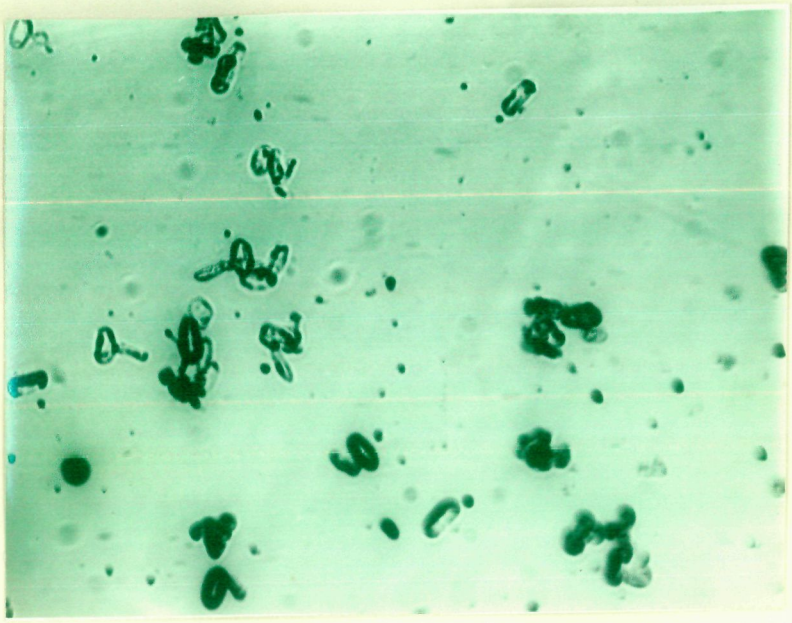


FIG. 4 A

FIG 4B

were cylindrical in shape (Fig. 5 & 6), measuring 24.5-42.0 x 10.5-14.0 µm; 24.5-38.5 x 10.5-15.5 µm; 21.0-35.0 x 10.5-14.0 µm and 21.0-38.5 x 10.5-14.0 µm respectively (Table 3). The conidia on all the hosts ranged from 21.0-42.0 x 10.5-15.5 µm. Fibrosin bodies were absent in conidia and on germination they gave rise to the germ tube with complex appressoria (Fig.7).

The cleistothecia appeared late in season i.e. April on the living leaves of D. carota. They were dark brown in colour and spherical in shape (Fig. 8) having numerous basally inserted myceloid appendages. The number of asci in each cleistothecium ranged from 4-7. The shape of asci were obovate to subglobose with 3-6 elliptical ascospores per ascus (Fig. 9). The size of cleistothecia ranged from 73.5-129.5 µm. While that of asci and ascospores from 42.0-63.0 x 24.5-38.5 µm and 17.5-28.0 x 7.0-14.0 µm respectively (Table 4). Thus, the powdery mildew on the above was E. heraclei.

HOST RANGE AND VARIETAL RESISTANCE -

A - Host range - It is clear from the table 5 that out of ten cultivated and wild composits tested against the three isolates of E. cichoracearum from X. strumarium, H. annuus and D. variabilis; Co. sulphunus, S. oleraceus and X. strumarium

Fig. 5 (A) A plant of *Daucus carota* infected with powdery mildew.

(B) Leaves of *D. carota* infected with powdery mildew.

(C) Leaves, stem and Fruits of *Anethum graveolens* infected with powdery mildew.

FIG. 5 A

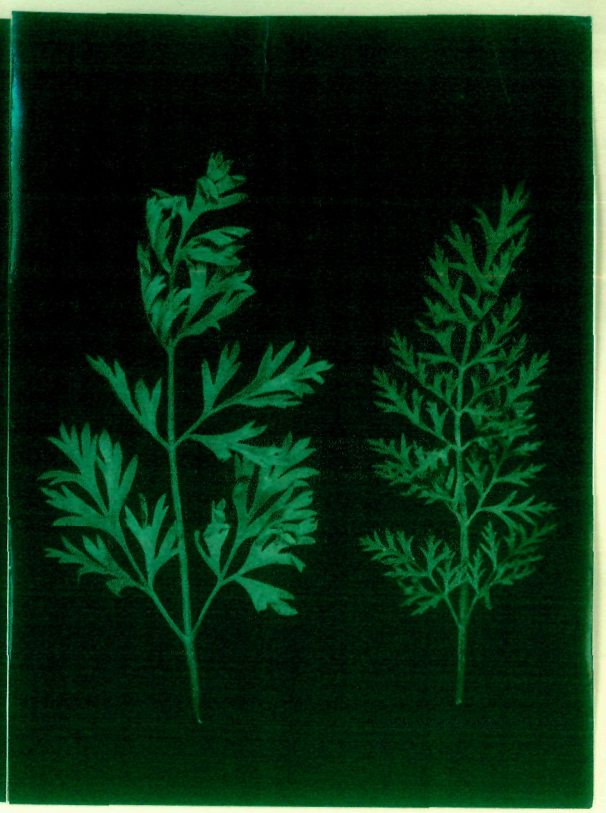


FIG. 5 B

FIG. 5 C

Fig.6 Conidia of *Erysiphe heraclei* from *Daucus carota*.

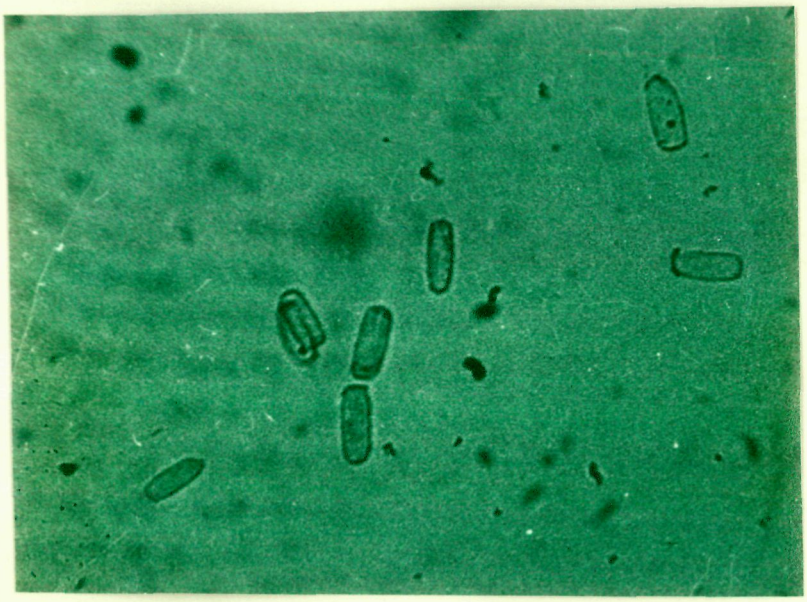


FIG. 6

Fig. 7 (A) Germinating conidia of Erysiphe heraclei.

(B) Close-up.

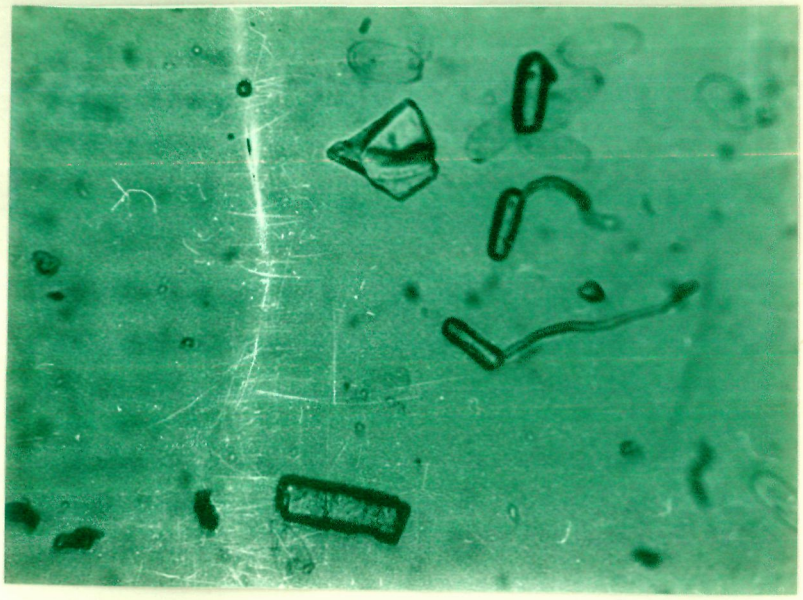


FIG. 7 A

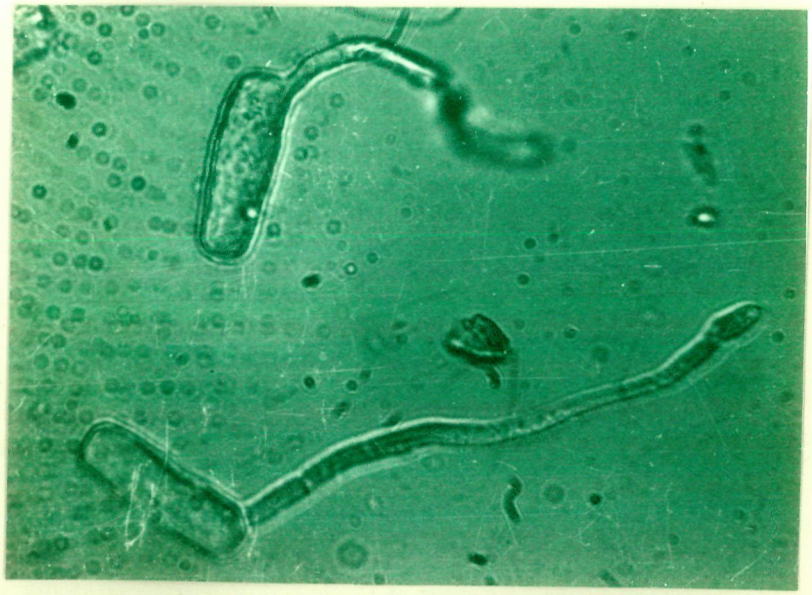


FIG. 7 B

Fig. 8 (A) Cleistothecia of *Erysiphe heraclei* from *Daucus carota*.

(B) A cleistothecium of *E. heraclei* (close-up)

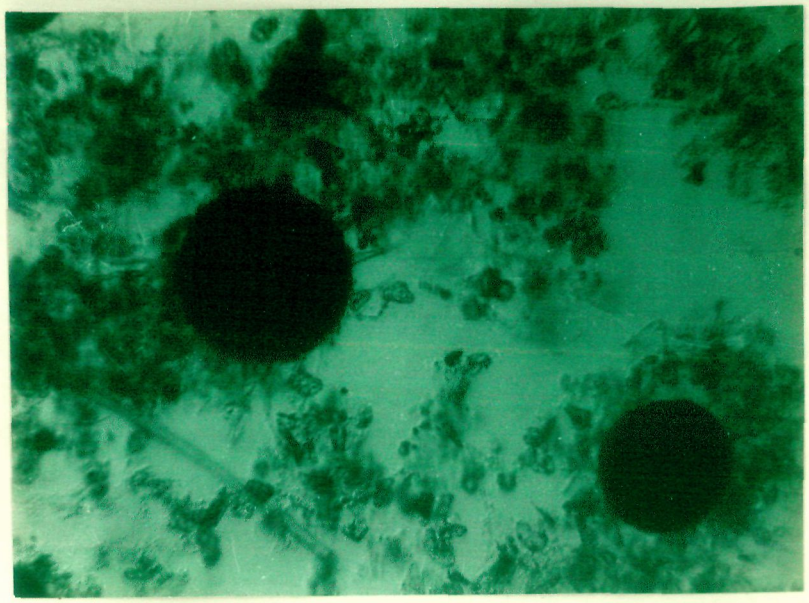


FIG. 8 A

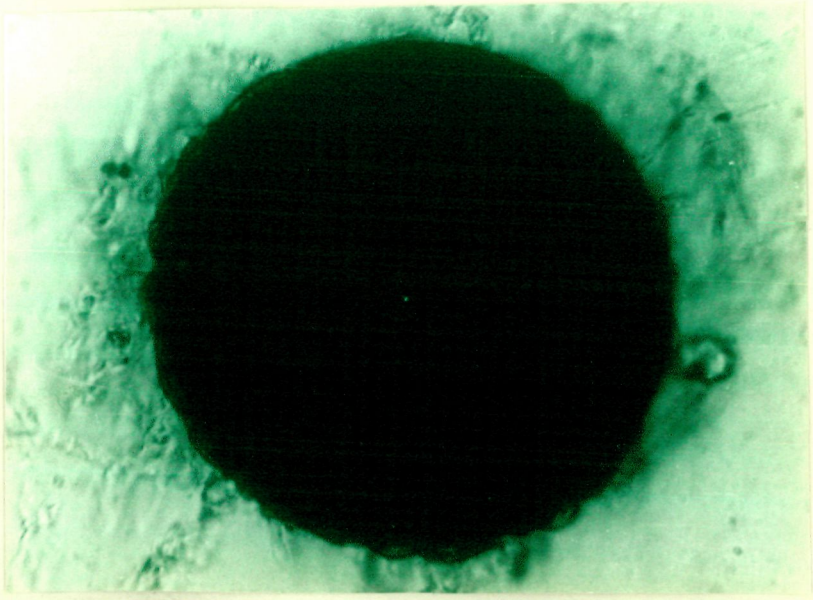


FIG. 8 B

Fig. 9 (A) Ruptured cleistothecium of Erysiphe heraclei showing asci.

(B) As Ascus with 6 ascospores.

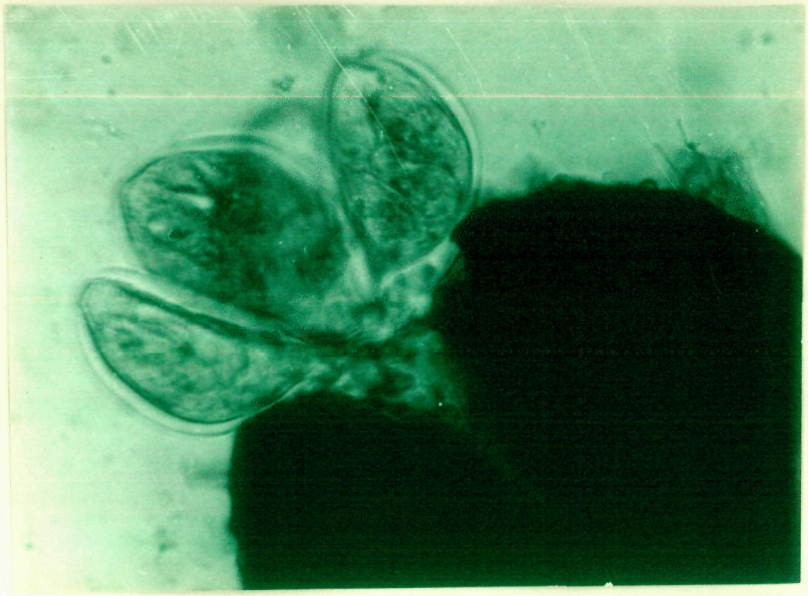


FIG. 9 A

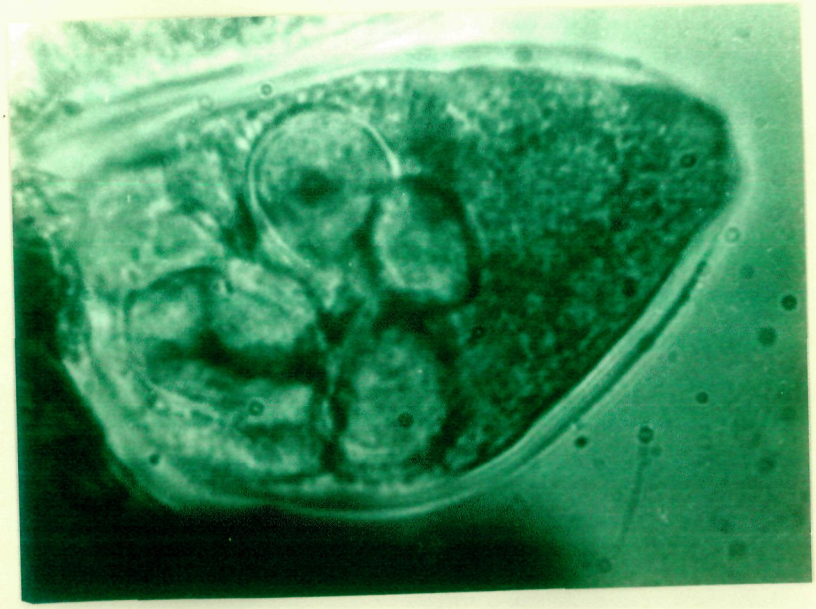


FIG. 9 B

Table - 4

Measurements of cleistothecia of powdery mildew of *Daucus carota*

Characters studied	Range with Mean µm
CLEISTOTHECIA	
Diameter	73.5 - 129.5 (97.25)
Asci	
Length	42.0 - 63.0 (52.50)
Width	24.5 - 38.5 (31.75)
ASCOSPORES	
Length	17.5 - 28.0 (23.75)
Width	7.0 - 14.0 (10.85)

Data based on measurements of 100 ± 20 cleistothecia.

Table - 5

Response of eight cultivated and two wild composits against three isolates of *E. cichoracearum*, in glass house and in the Field.

Plants inoculated	Isolates from					
	X. strumarium		*H. annuus*		*Dahlia variabilis*	
	Glass house	Field	Glass house	Field	Glass house	Field
Chrysanthemum carinatum	R	R	R	R	R	R
Calendula officinalis	R	R	R	R	R	R
Cosmos sulphunus	S	S	R	R	R	R
Cinerania spp.	R	R	R	R	R	R
Dahlia variabilis	R	R	S	S	S	S
Zinnia elegans	R	R	S	S	S	S
Helianthus annuus	R	R	S	S	S	S
Aster spp.	R	R	R	R	R	R
Xanthium strumarium	S	S	R	R	R	R
Sonchus oleraceus	S	S	R	R	R	R

R = Resistant

S = Susceptible

were susceptible to X. strumarium isolate; D. variabilis, Z. elegans and H. annuus were susceptible to the isolated from H. annuus and D. variabilis in glass house as well as in the field studies.

However, the cucurbit isolates of E. cichoracearum from Coccinia cordifolia and Benincasa hispida failed to cause infection on any of the cultivated and wild composits (Table 6).

It is clear from the table 7 that out of six cultivated umbelliferous plants tested against isolates of E. heraclei (from D. carota, C. sativum and A. graveolens), only Ca. copticum was found resistant.

D. carota, C. sativum and A. graveolens were susceptible to the all three isolates; F. vulgare was susceptible to the isolates of C. sativum and A. graveolens while Cu. cyminum was susceptible to the isolates of C. sativum both in glass house as well as in the field.

Isolates of E. polygoni obtained from the Pisum sativum, Cassia occidentalis and Chenopodium ambrosoides failed to cause infection on any of the cultivated umbelliferous hosts tested (Table - 8).

B- Varietal Screening- Three varieties of H. annuus viz., Miniature japanese, Sungold dwarf and Bronze hybrid were highly susceptible in glass house but susceptible in the field and Var. chrysanthemum flower mixed was susceptible in glass house and moderately resistant in the field to the two composit isolates of E. cichoracearum obtained from H. annuus and Z. elegans (Table 9).

Table - 6

Reaction of eight cultivated and two wild composit& plants against *E. cichoracearum* (obtained from cucurbits), in glass house and in the field.

Plant inoculated	Isolates from			
	Coccinia cordifolia		*Benincasa hispida*	
	Glass house	Field	Glass house	Field
Chrysanthemum carinatum	R	R	R	R
Calendula officinalis	R	R	R	R
Cosmos sulphunus	R	R	R	R
Cineraria spp.	R	R	R	R
Helianthus annuus	R	R	R	R
Zinnia elegans	R	R	R	R
Aster spp.	R	R	R	R
Dahlia variabilis	R	R	R	R
Xanthium strumarium	R	R	R	R
Sonchus oleraceus	R	R	R	R

R = Resistant

Table - 7

Reaction of six umbelliferous plants against *E. heraclei* in glasshouse and in field.

Inoculated hosts	Isolates from					
	D. carota		*C. sativum*		*A. graveolens*	
	Glass house	Field	Glass house	Field	Glass house	Field
Daucus carota	S	S	S	S	S	S
Coriandrum sativum	S	S	S	S	S	S
Foeniculum vulgare	R	R	S	S	S	S
Anethum graveolens	S	S	S	S	S	S
Cuminum cyminum	R	R	S	S	R	R
Carum copticum	R	R	R	R	R	R

R = Resistant

S = Susceptible

Table - 8

Response of six umbelliferous plants to three non-umbelliferous isolates of *E. polygoni*.

Inoculated host	Reaction against isolates from					
	Pisum sativum		*Cassia Occidentalis*		*Chenopodium ambrosoides*	
	Glass house	Field	Glass house	Field	Glass house	Field
Daucus carota	R	R	R	R	R	R
Coriandrum sativum	R	R	R	R	R	R
Foeniculum vulgare	R	R	R	R	R	R
Cuminum cyminum	R	R	R	R	R	R
Anethum graveolens	R	R	R	R	R	R
Carum copticum	R	R	R	R	R	R

R = Resistant

Table - 9

Response of four varieties of *Helianthus annuus* to three composit isolates of *Erysiphe cichoracearum*.

Varieties	Source of Inoculum			
	H. annuus		*Z. elegans*	
	Glass house	Field	Glass house	Field
1. Miniature japanese	4	3	4	3
2. Sungold dwarf	4	3	4	3
3. Bronge hybrid	4	3	4	3
4. Chrysanthemum flower mixed	3	2	3	2

2 = Moderately resistant
3 = Susceptible
4 = Highly susceptible

Table - 10

Response of four varieties of Zinnia elegans to three composit isolates of E. cichoracearum.

Varieties	Source of Inoculum			
	H. annuus		Z. elegans	
	Glass house	Field	Glass house	Field
1. Persian carpet	3	3	4	3
2. Linearis orange	3	3	4	3
3. California Giant mixed	3	3	4	3
4. Lilliput mixed	3	3	4	3

3 = Susceptible

4 = Highly susceptible

Table - 11

Response of four varieties of Dahlia sp. to three composit isolates of E. cichoracearum.

Varieties	Source of Inoculum			
	H. annuus		Z. elegans	
	Glass house	Field	Glass house	Field
1. Large flower mixed	3	2	3	2
2. Unwins hybrid mixed	3	2	3	2
3. Super Giant mixed	3	2	3	2
4. Decorative mixed	3	2	3	2

2 = Moderately Resistant

3 = Susceptible

4 = Highly susceptible

Table - 12

Response of four varieties of *Daucus carota* to two umbelliferous isolates of *E. heraclei*.

Varieties	Source of Inoculum			
	Daucus carota		*Coriandrum sativum*	
	Glass house	Field	Glass house	Field
1. Pusa kesar	4	3	4	3
2. Tender sweet	4	3	4	3
3. Danvers half long	4	3	4	3
4. Nantes early half long	4	3	4	3

3 = Susceptible

4 = Highly susceptible

Varieties of Z. elegans viz. Persian carpet, Linearis orange, California giant mixed and Lilliput mixed were susceptible both in glass house and in the field to the isolate of E. cichoracearum from H. annuus but highly susceptible in glass house to the isolate from Z. elegans (Table - 10). Cultivars of Dahlia Sp. viz. Large flower mixed, Unwins hybrid mixed, super giant mixed and Decorative mixed were susceptible in glass house and moderately resistant in field to H. annuus and Z. elegans isolates (Table 11).

D. carota cv. Pusa kesar, Tender sweet, Danvers half long and Nantes early half long were highly susceptible and susceptible both in glass house and field respectively to the D. carota and C. sativum isolates of E. heraclei (Table-12).

GERMINATION OF CONIDIA OF E. CICHORAREARUM AND E. HERACLEI

(A) Effect of temperature on germination:

Conidia of E. cichorarearum (obtained from X. strumarium and H. annuus) failed to germinate at 0.5°C. Germination was very low at 10°C and in trace at 32°C. The percentage of germination after 72 hours at 17 and 20°C was 54.5 & 50.0

for X. strumarium and 61.3 & 60.5 for H. annuus respectively. At these temperature the germination was initiated 12 hours after incubation. Highest germination after 72 hours occurred at the temperature ranged from 17-20°C. At 25°C germinated conidia showed deformation after 60 hours (Table 13).

Conidia of E. heraclei obtained from A. graveolens, C. sativum and D. carota failed to germinate at 0-5°C. The percentage of germination after 72 hours at 20 and 25°C was 45.5 & 45.0 for A. graveolens, 47.7 & 45.5 for C. sativum and 50.0 & 47.0 for D. carota respectively. The highest percentage of germination occurred at the ranged from 20-25°C. At 32°C the conidia germinated in trace and started deforming at 48 hours (Table 14).

(B) Effect of Relative humidity on germination - Conidia of E. cichoracearum and E. heraclei failed to germinate in free water. There was no germination at 66 and 78 percent relative humidities, and the germination of both was in trace to very low at 81 percent relative humidity. Highest germination take place at 95-100 percent relative humidity. The germination was initiated after 12 hours of incubation at the relative humidity of 95 and 100 percent. The germination of conidia of

E. cichoracearum after 72 hours at 90, 95 and 100 percent relative humidities at 20°C was 30.0, 40.0 & 45.0 for X. strumarium isolate and 30.0, 47.0 & 50.0 for H. annuus isolate respectively (Table 15). While the germination of conidia of E. heraclei was 33.5, 37.5 & 38.0 for A. graveolens isolate, 35.0, 37.0 & 40.8 for C. sativum isolate and 36.7, 40.0 & 42.3 for D. carota isolate respectively (Table 16).

EFFECT OF DIFFERENT TEMPERATURES AND RELATIVE HUMIDITIES ON THE DEVELOPMENT OF POWDERY MILDEW ON DETECHED LEAVES OF H. ANNUUS AND Z. ELEGANS INOCULATED WITH E. CICHORACEARUM:

In all the three varieties of H. annuus, powdery mildew colonies appeared on detached leaves after 7,5 and 7 days at, 10, 17-20 and 25°C respectively at 60 percent relative humidity, and after 5 and 6 days at 20 and 25°C both at 80 & 90 percent relative humidities. Powdery mildew did not appear at 10°C at 80 and 90 percent relative humidity. In the two varieties of Z. elegans, the time required for the appearance of powdery mildew was the same with H. annuus (Table-17).

Table - 13

Germination of conidia of Erysiphe cichoracearum at different temperatures and 100 percent relative humidity.

Temperature in °C	Percentage germination of conidia/hrs.																			
	Conidia from*																			
	8hrs.			12hrs			24hrs			36hrs			48hrs			60hrs			72hrs		
	*X. strumarium	*H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%
0	-	-		-	-		-	-		-	-		-	-		-	-		-	-	
5	-	-		-	-		-	-		-	-		-	-		-	-		-	-	
10	-	-		-	-		T	T		10.0	12.5	1.74	14.0	16.8	3.45	15.0	17.3	1.91	15.0	18.6	1.06
17	-	-		10.5	20.7	2.61	21.3	32.3	3.88	25.8	42.0	3.79	31.6	50.0	4.57	49.0	60.1	3.60	54.5	61.3	4.78
20	-	-		11.2	20.0	1.02	18.8	34.2	4.87	25.1	41.7	4.01	27.8	49.2	3.66	50.0	56.5	3.24	50.0	60.5	1.94
25	-	-		12.0	18.0	0	15.0	28.7	2.49	20.0	36.4	2.55	25.0	40.6	1.01	38.2	42.9	3.17	39.0	45.0	0
32	-	-		T	T	-	T	T	-	T	T	-	Td	Td	-	Td	Td		Td	Td	

T = Germination in trace
Td = Germination in trace but conidia deformed.
- = no germination

Table - 14

Germination of conidia of Erysiphe heraclei at different temperatures and 100% relative humidity.

Temperature in °C	Percentage germination of conidia/hrs.																							
	Conidia from*																							
	8hrs			12hrs				24hrs				36hrs				48hrs				60hrs				72hrs			
	*A. graveolens	*C. sativum	*D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%
0	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	
5	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	
10	-	-	-		-	-	-		12.5	15.0	15.0	1.61	12.5	21.3	20.0	1.97	20.0	25.0	23.5	1.12	22.5	25.0	25.0	1.09	22.5	25.0	26.9	2.14
17	-	-	-	12.5	10.0	13.7	1.02	20.0	20.0	20.0	1.57	23.5	20.0	23.8	3.69	28.7	31.5	30.0	4.07	37.5	39.0	41.5	2.42	40.0	40.0	42.8	2.49
20	-	-	-	10.0	10.0	10.0	0	20.0	20.0	20.0	3.07	27.5	22.5	25.0	4.78	30.0	31.5	36.5	2.05	40.7	40.0	45.7	3.73	45.5	47.7	50.0	5.68
25	-	-	-	10.0	10.0	10.0	0	17.5	17.9	15.7	2.87	29.0	22.8	26.5	3.69	37.7	35.9	38.0	4.51	43.0	41.5	43.5	2.99	45.0	45.5	47.0	5.47
32	-	-	-	T	T	T		T	T	T		T	T	T		Td	Td	Td		Td	Td	Td		Td	Td	Td	

\- = No germination
T = Germination in trace
Td = Germination in trace but conidia deformed.

Table - 15

Germination of conidia of Erysiphe cichoracearum at different relative humidities and 20°C.

Percentage of Relative Humidity	Percentage of germination of conidia/hrs.																	
	Conidia from*																	
	12hrs			24hrs			36hrs			48hrs			60hrs			72hrs		
	*X. strumarium	*H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%	X. strumarium	H. annuus	L.S.D. at 5%
66	-	-		-	-		-	-		-	-		-	-		-	-	
78	-	-		-	-		-	-		-	-		-	-		-	-	
81	-	-		-	-		T	T		T	T		T	T		T	T	
90	-	-		7.56	9.0	.52	10.0	10.0	2.68	15.0	16.5	6.95	27.0	29.0	1.66	30.0	30.0	2.29
95	8.0	9.96	1.08	10.0	11.0	1.33	14.5	15.0	2.33	20.5	22.0	4.15	38.4	40.0	5.06	40.0	47.0	4.90
100	10.0	12.0	1.14	12.5	14.0	3.35	17.0	19.0	5.35	26.7	28.0	6.59	42.5	45.0	6.72	45.0	50.0	6.22
Water	-	-		-	-		-	-		-	-		-	-		-	-	

T = Germination in trace

- = No Germination

Table - 16

Germination of conidia of Erysiphe heraclei at different relative humidities and 20°C.

Percentage of Relative humidity	Percentage germination of conidia/hrs. Conidia from*																					
	12hrs				24hrs				36hrs				48hrs				60hrs				72hrs			
	*Anethum graveolens	*Coriandrum sativum	*Daucus carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%	A. graveolens	C. sativum	D. carota	L.S.D. at 5%
66	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	
78	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	
81	-	-	-		T	T	T		T	T	T		17.5	20.0	20.0	.89	20.0	20.0	20.0	0	20.0	20.0	20.0	0
90	-	-	-		10.0	9.0	11.7	1.19	11.5	13.7	15.0	2.28	17.5	23.0	22.0	2.57	21.0	25.0	26.7	3.45	33.5	35.0	36.7	3.18
95	T	T	T		10.0	11.0	13.5	1.88	11.5	14.5	15.0	3.13	19.0	22.0	23.0	4.27	24.0	28.0	29.9	3.87	37.5	37.0	40.0	4.33
100	10.0	10.0	10.0	0	20.0	20.0	20.0	3.35	20.0	23.7	22.5	2.73	25.0	29.0	29.0	6.24	29.5	33.5	35.9	5.72	38.0	40.8	42.3	6.62
Water	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	

- = No Germination

T = Germination in trace.

Table - 17

Effect of different temperatures and relative humidities for the appearance of powdery mildew on detached leaves of different varieties of H. annuus and Z. elegans inoculated with E. cichoracearum.

Varieties	Temperature in °C																	
	5°C			10°C			17°C			20°C			25°C			32°C		
	Percentage of Relative humidity																	
	60	80	90	60	80	90	60	80	90	60	80	90	60	80	90	60	80	90
Helianthus annuus																		
1. Miniature Japanese	(-)	(-)	(-)	(7)	(-)	(-)	(5)	(5)	(5)	(5)	(5)	(5)	(7)	(6)	(6)	(-)	(-)	(-)
2. Sungold dwarf	(-)	(-)	(-)	(7)	(-)	(-)	(5)	(5)	(5)	(5)	(5)	(5)	(7)	(6)	(6)	(-)	(-)	(-)
3. Bronge hybrid	(-)	(-)	(-)	(7)	(-)	(-)	(5)	(5)	(5)	(5)	(5)	(5)	(7)	(6)	(6)	(-)	(-)	(-)
Zinnia elegans																		
1. Linearis	(-)	(-)	(-)	(7)	(-)	(-)	(5)	(5)	(5)	(5)	(5)	(5)	(7)	(6)	(6)	(-)	(-)	(-)
2. Lilliput mixed	(-)	(-)	(-)	(7)	(-)	(-)	(5)	(5)	(5)	(5)	(5)	(5)	(7)	(6)	(6)	(-)	(-)	(-)

(-) = Not appeared

Figure in ( ) indicate the time in days for the appearance of powdery mildews.

COMMON HOST TEST - Since Cucumis sativus (cucumber) has been reported a common host to both Erysiphe cichoracearum and Sphaerotheca fuliginea, it was considered desirable to study the development of the two on this host when inoculated simultaneously. There was moderate infection when inoculated with E. cichoracearum only but severe when inoculated with S. fuliginea only (Fig. 10-A). Both the pathogens developed equally on leaves of the host plant. E. cichoracearum and S. fuliginea both developed equally well on a single leaf when half portion of this was inoculated with conidia of E. cichoracearum and half with conidia ofn S. fuliginea (Fig. 10-B). Both the pathogens can compete very well on the same host and the same leaf (Table 18).

After 60-65 days of inoculations, perithecia were observed on stems and leaves. The detailed examination revealed that they were of S. fuliginea and not of E. cichoracearum. E. cichoracearum did not form the perithecia.

In earlier studies it has been shown that different members of the family compositae are hosts of powdery mildew, Erysiphe cichoracearum. Besides the pathogen also infects cucurbits (Vasudeva, 1960; Rajendran, 1965; Mathur et al., 1971; Khan et al, 1971 & Khan et al. 1972). It is not known

Fig. 10(A) Leaves of *Cucumis sativus* infected with *Sphaerotheca fuliginea* and *Erysiphe cichoracearum*.

(B) A single leaf of *Cucumis sativus* infected with *S. fuliginea* and *E. cichoracearum*.

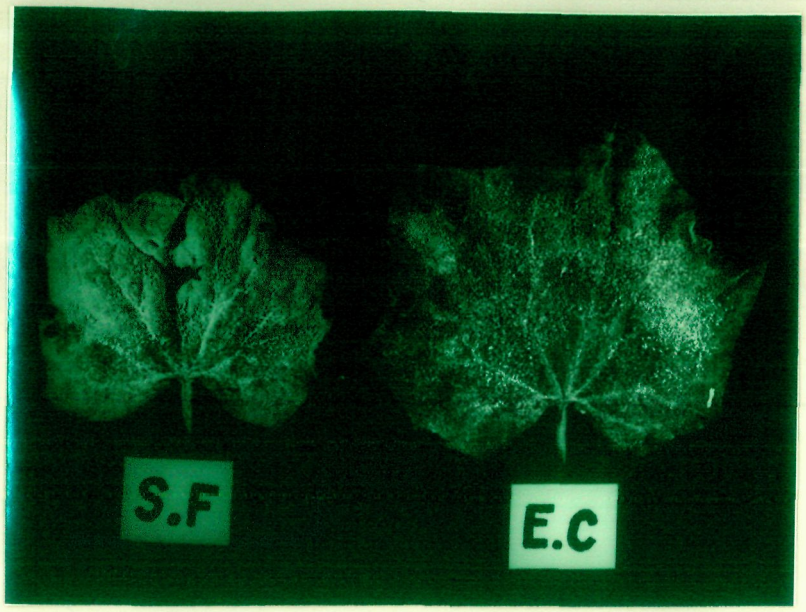


FIG. 10 A

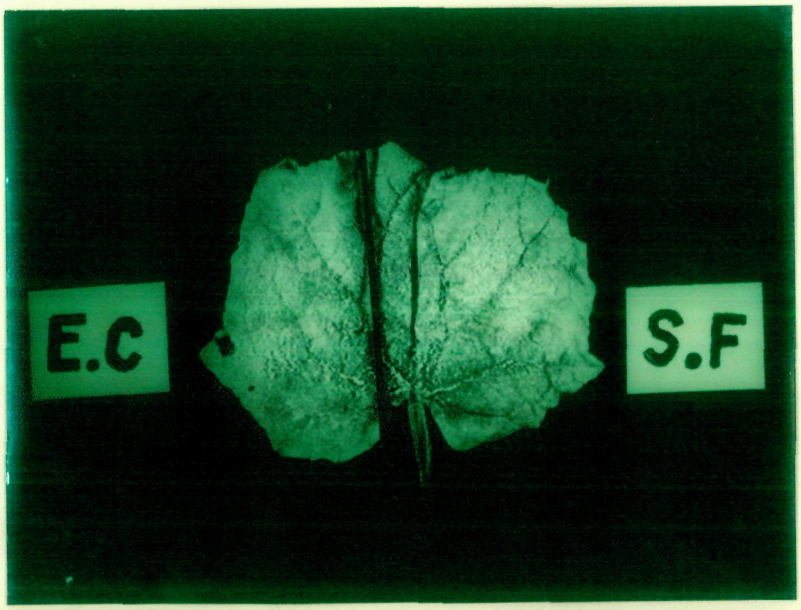


FIG. 10 B

Table - 18

Cucumis sativus a common host for *E. cichoracearum* and *S. fuliginea*.

Treatments	Appearance of mildew	Production of perithecia
A. Leaves inoculated by *E. cichoracearum* only.	Moderate	-
B. Leaves inoculated by *S. fuliginea* only	Severe	Produced
C. *E. cichoracearum* and *S. fuliginea* both inoculated on different leaves of the same plant.	Mildew appeared by both pathogens	Produced by *S. fuliginea* only
D. Half portion of a leaf inoculated with *E. cichoracearum* and half with *S. fuliginea*.	Both pathogens appeared on the same leaf.	-
E. Control	-	-

whether the composits are hosts of root knot nematode and if they may be involved in the fungus nematode interaction. Therefore in the present studies an attempt has been made to find out if such plants and certain other cucurbits plants which are infected with powdery mildew, are also hosts to root-knot nematode, Meloidogyne incognita so that in nature, the interaction of the two pathogens can be avoided.

SUSCEPTIBILITY OF DIFFERENT COMPOSITS TO ROOT KNOT NEMATODE

It is clear from the table 19 that root knot infection developed on Calendula officinalis, Dahlia variabilis, Cosmos sulphunus and Cineraria spp. where galling due to root-knot nematode was observed on the roots. The remaining plants, however, remained free of infection. The infected plants showed reduction in growth. On Cosmos sulphunus, the larvae, although penetrated but did not metamorphise in to mature females.

Results presented in table 20 show that in Cineraria spp. and D. variabilis where the root-knot index was 3.00, the mean body length and swidth of the female were 502.32 x 298.0 µm and 517.72 x 320.0 µm respectively. However, in Cl. officinalis

Table-19

Susceptibility of different composit plants to single egg mass population of *Meloidogyne incognita* and effect on growth of plants and root-knot development.

Host	Length of plant (cm)	Dry weight of plant (gm)	No.of Galls/ plant	Root-knot Index	Population of Nematode		Total population
					Root population /5g	Soil population /250g.	
Chrysanthemum carinatum							
Uninoculated	40.0	1.5	-	-	-	-	-
Inoculated	39.2	1.5	-	-	-	-	-
Calendula officinalis							
Uninoculated	51.5	2.1	-	-	-	-	-
Inoculated	43.7	1.7	78	4	390	570	960
Helianthus annuus							
Uninoculated	57.5	2.1	-	-	-	-	-
Inoculated	57.2	2.0	-	-	-	-	-
Zinnia elegans							
Uninoculated	50.3	1.9	-	-	-	-	-
Inoculated	50.0	1.9	-	-	-	-	-
Dahlia variabilis							
Uninoculated	37.5	2.8	-	-	-	-	-
Inoculated	34.0	2.5	49	3	185	320	505
Cosmos sulphunus							
Uninoculated	60.0	1.4	-	-	-	-	-
Inoculated	60.0	1.3	3	1	6	-	6
Cineraria spp.							
Uninoculated	28.7	2.0	-	-	-	-	-
Inoculated	25.1	1.7	44	3	150	287	437
L.S.D. at 5% level	3.01	.27	17.26	.79	143.21	178.19	253.72

Each figure is the mean of five replicates.

Table - 20

Effect of inoculating different composit plants with single egg mass population of *M. incognita* on the morphometrics of females of the nematode.

Hosts	Body length µm	Body width µm	Neck length µm	Neck width µm	Median bulb µm	Median bulb µm
Cineraria spp.	502.32±42.67 (8.49)	298.0±36.50 (12.24)	200.0±15.03 (7.15)	75.0±5.48 (7.30)	35.66±2.01 (5.66)	35.0±0.98 (2.8)
Dahlia variabilis	517.72±41.32 (7.98)	320.0±26.31 (8.22)	209.33±16.69 (7.97)	78.0±7.33 (9.40)	38.0±1.98 (5.21)	35.31±1.87 (5.29)
Calendula officinalis	658.50±36.77 (5.58)	370.5±37.25 (10.75)	278.23±30.09 (10.87)	90.0±10.28 (11.42)	39.5±2.12 (5.36)	37.89±1.96 (4.46)

Figures in parenthesis indicate CV.

Each figure is mean of twenty females.

with root-knot index 4.00, the size both length and width increased to 658.50 x 370.50 /um respectively. It shows that on susceptible plants not only the root-knot index was high but the size of female was also on higher side. Other measurements of the body were also influenced like wise.

INTERACTION OF POWDERY MILDEW AND ROOT-KNOT NEMATODE

It is clear from the table 21 that there was reduction in growth of D. variabilis when inoculated with either fungus or the nematode. However, the reduction increased when the plants were inoculated with the two pathogens. There was no marked difference in growth of plants with simultaneous or sequential inoculations with the pathogens. The root knot index was 2.00 when inoculated with nematode alone, and 3.00 when inoculated with fungus and nematode simultaneously and sequentially. The final population of the nematode was more when inoculated with two pathogens. It appeared that the inoculation of the plant with powdery mildew resulted in more development of root-knot(Fig.11).

The morphometric values of the females were low in plants inoculated both with fungus and nematode (Table 22). When plants were inoculated with both the pathggens, the

Table - 21

Effect of powdery mildew fungus *E. cichoracearum* and Root knot nematode *M. incognita* on growth of *Dahlia variabilis*.

Treatments	Length of the plants (cm)	Dry wt. of the plants (gm)	No.of Galls	No. of egg masses/ plant	Root-knot Index	Population of mematode		Total population
						Soil population /250g.	Root population /5g.	
1. Control	38.7	3.0	-	-	-	-	-	-
2. Fungus alone	33.9	2.7	-	-	-	-	-	-
3. Nematode alone	32.0	2.6	48	60	2.0	507	190	697
4. Fungus and nematode simultaneously	28.7	2.2	59	77	3.0	669	245	914
5. Fungus after 15 days of nematode inoculation	30.0	2.2	63	80	3.0	625	257	882
L.S.D. at 5% level.	5.07	0.43	10.03	11.17	.57	56.07	22.72	121.63

Each figure is replicate of five plants.

Fig. 11. Effect of inoculating Dahlia variabilis with Erysiphe cichoracearum and root knot nematode Meloidogyne incognita on the growth of the plant and the population of the nematode.

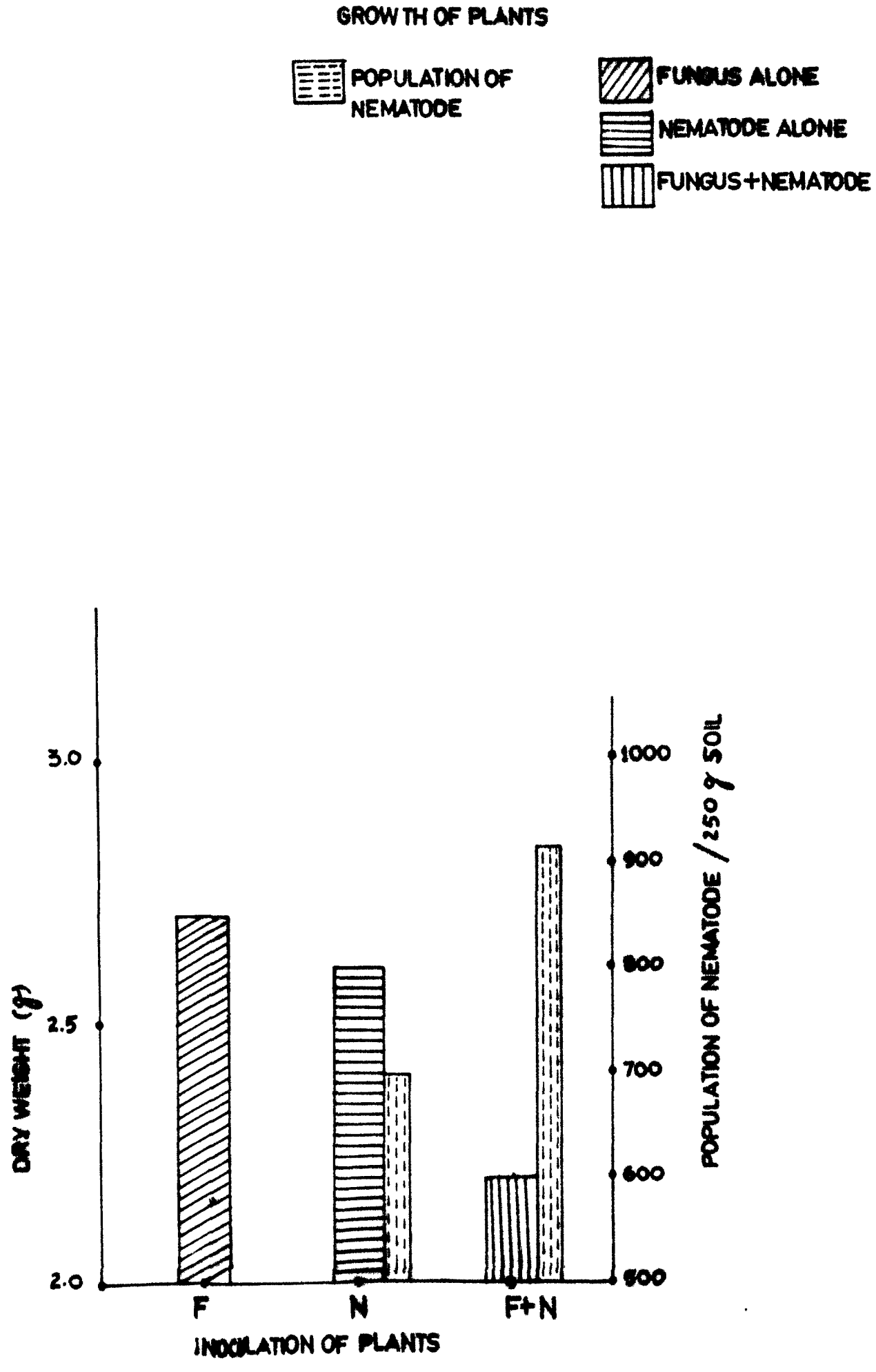

GROWTH OF PLANTS
POPULATION OF NEMATODE
FUNGUS ALONE
NEMATODE ALONE
FUNGUS+NEMATODE
DRY WEIGHT (g)
3.0
2.5
2.0
1000
900
800
700
600
500
POPULATION OF NEMATODE / 250 g SOIL
F
N
F+N
INOCULATION OF PLANTS

FIG. 11

Table - 22

Effect of powdery mildew on the morphometrics of females of nematode, *M. incognita* in *Dahlia variabilis*.

Treatments	Body length µm	Body width µm	Neck length µm	Neck width µm	Median bulb length µm	Median bulb width µm
Plants inoculated with nematode alone	523.65±69.73 (13.32)	331.75±41.87 (12.62)	209.33±30.09 (14.37)	85.0±10.28 (12.09)	38.6±2.25 (5.83)	35.89±1.96 (5.46)
Plants inoculated with nematode and fungus	491.89±78.62 (15.98)	302.25±50.17 (16.59)	200.0±16.69 (8.34)	93.45±12.63 (13.51)	38.0±2.12 (5.38)	35.07±1.87 (5.04)
L.S.D. at 5% level	20.87	14.93	15.97	9.07	2.03	2.19

Each figure is the replicate of 20 females.

mean body length and width of female were 491.89 x 302.25 µm as against 523.65 x 331.75 µm in nematode alone. The measurements of other characters of the female were not materially influenced.

Similar results were observed when Lagenaria leucantha (Fig. 12) and Cucumis sativus were inoculated with nematode alone and fungus nematode (Table 23). Results presented in table 24 show that the size, both length and width of female were reduced when plants inoculated with fungus and nematode both.

It is clear from table 23(b) that powdery mildew disease was more severe when the fungus was associated with nematode but there was no change in measurements of conidia.

EFFECT OF MOISTURE LEVELS ON THE DEVELOPMENT OF ROOT-KNOT NEMATODE, M. INCOGNITA AND INTENSITY OF POWDERY MILDEW, S. FULIGINEA IN L. LEUCANTHA AND C. SATIVUS.

It is clear from tables 25 & 26 that the growth of plants, root knot development and multiplication of the nematode increased with the increase in moisture levels up to 40 percent followed by a decrease at 50 percent. The development of powdery mildew, however increased with increase in the moisture levels (Fig. 13).

Fig. 12. Effect of inoculating *Lagenaria leucantha* with *Sphaerotheca fuliginea* and *Meloidogyne incognita* on the growth of the plant and the population of the nematode.

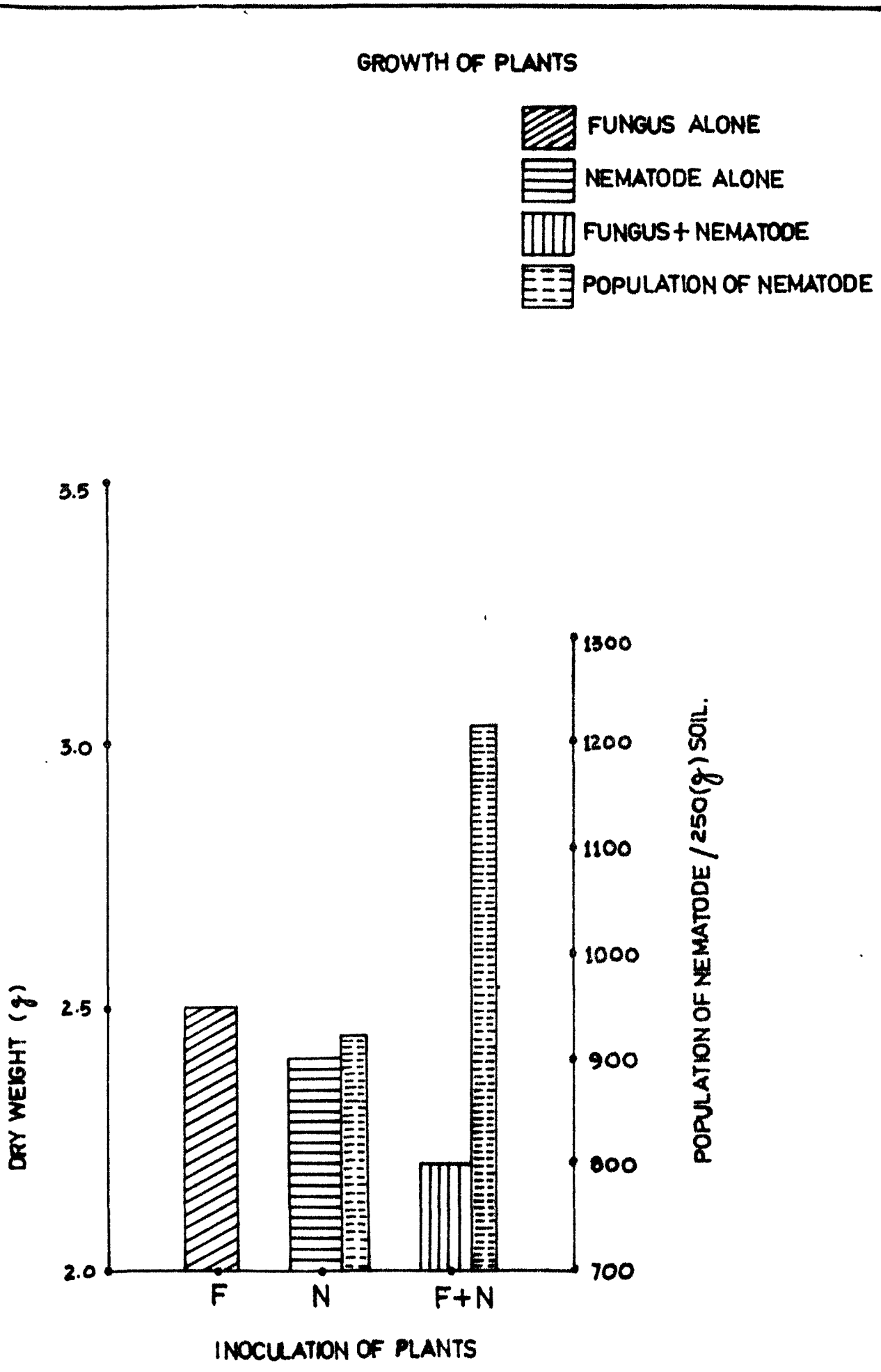

GROWTH OF PLANTS
FUNGUS ALONE
NEMATODE ALONE
FUNGUS + NEMATODE
POPULATION OF NEMATODE
3.5
3.0
2.5
2.0
DRY WEIGHT (g)
1300
1200
1100
1000
900
800
700
POPULATION OF NEMATODE / 250(g) SOIL.
F
N
F+N
INOCULATION OF PLANTS

FIG. 12

Fig. 12. A. Effect of powdery mildew, *Sphaerotheca fuliginea* on the growth of *Lagenaria leucantha*.

B. Effect of powdery mildew *S. fuliginea* and root-knot nematode *M. incognita* on the growth of *L. leucantha*.

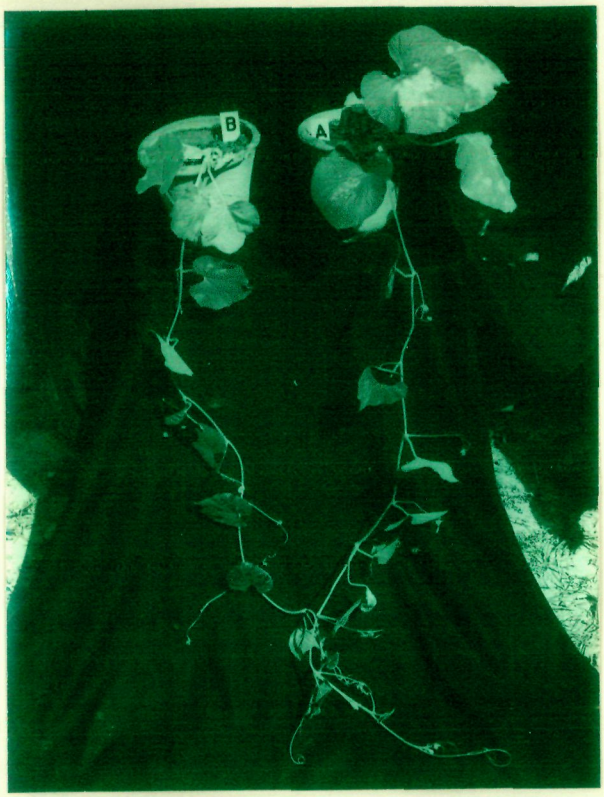


FIG. 12.

Table - 23

Effect of powdery mildew fungus, S. fuliginea and root-knot nematode M. incognita on the growth of Lagenaria leucantha and Cucumis sativus.

Treatments	Lagenaria leucantha							Cucumis sativus						
	Length of Plants (cm)	Dry weight of Plants (gm)	No.of Galls	Root-knot Index	Population of nematode			Length of plants (cm)	Dry weight of Plants (gm)	No.of Galls	Root-knot Index	Population of Nematode		
					Soil population	Root Population	Total population					Soil Population /250g.	Root population /5g.	Total Population
Control	117.0	3.2	-	-	-	-	-	73.6	5.2	-	-	-	-	-
Fungus alone	95.0	2.5	-	-	-	-	-	62.5	4.8	-	-	-	-	-
Nematode alone	91.3	2.4	68	3	749	173	922	58.8	4.6	56	3	497	150	647
Fungus and nematode simultaneously	89.0	2.2	82	4	986	230	1216	46.4	4.1	72	4	687	212	899
Fungus after 15 days of nematode inoculation	90.0	2.2	89	4	889	217	1106	47.2	4.1	75	4	715	198	913
L.S.D. at 5% level	4.92	0.35	10.17	0.81	72.34	31.75	182.64	5.16	0.49	11.24	0.67	66.90	28.49	174.71

Each figure is replicate of five plants.

Table 23(b)

Severity & measurements of conidia of Sphaerotheca fuliginea obtained from fungus alone and fungus-nematode infected plants of Lagenaria leucantha.

Treatments	Intensity of Powdery mildew	measurements of conidia	
		Length /µm	Width /µm
A. Plants inoculated with fungus alone	3	24.5 - 31.5 (28.35)	14.0 - 17.5 (15.75)
B. Plants inoculated with fungus and nematode both	4	24.5 - 31.5 (29.05)	10.5 - 17.5 (15.40)

3 = Susceptible

4 = Highly susceptible

Table - 24

Effect of powdery mildew fungus S. fuliginea on the morphometrics of females of nematode, M. incognita in case of L. leucantha and C. sativus.

Treatments	Body length µm	Body width µm	Neck length µm	Neck width µm	Median bulb length µm	Median bulb width µm
L. leucantha						
Plants inoculated with nematode alone	500.0-865.0	335.0-510.0	200.0-395.0	70.0-165.0	40.0-32.0	38.0-50.0
	610.25±109.25 (17.90)	490.5±51.88 (12.66)	279.5±71.79 (25.68)	112.1±30.74 (27.42)	46.0±3.76 (8.17)	43.5±3.85 (8.85)
Plants inoculated with nematode and fungus	430.0-790.0	245.0-420.0	180.9-390.0	75.0-145.0	35.0-55.0	40.0-50.0
	561.5±112.15 (19.97)	331.75±52.91 (15.94)	273.0±62.47 (22.88)	114.25±22.37 (19.58)	42.5±6.61 (15.35)	44.4±4.47 (10.06)
L.S.D. at 5% level.	9.53	14.93	15.91	9.17	3.88	2.89
C. sativus						
Plants inoculated with nematode alone	540.0-685.0	325.5-495.0	215.0-380.0	95.0-200.0	39.0-42.7	38.2-41.5
	601.5±78.62 (13.07)	382.0±128.52 (33.64)	288.5±57.49 (19.92)	137.0±48.70 (35.54)	41.9±1.77 (4.22)	40.0±2.07 (5.17)
Plants inoculated with nematode and fungus	490.0-650.0	300.0-455.0	215.0-350.0	90.0-200.0	35.0-40.0	35.0-40.0
	542.5±80.13 (15.54)	328.5±50.17 (13.61)	275.0±64.12 (23.31)	130.0±35.56 (27.35)	39.6±2.25 (5.68)	38.5±1.79 (4.65)
L.S.D. at 5% level	17.23	9.41	13.42	8.32	1.94	2.17

Each figure is the replicate of twenty females.
Figures in paranthesis indicates CV.

Table - 25

Effect of different moisture levels on the development of root knot nematode *M. incognita* and intensity of powdery mildew *S. fuliginea* in *Lagenaria leucantha*.

Treatments at different moistures levels(%)	Total length of plant (cm)	Fresh weight of plant (gm)	Dry weight of plant (gm)	No.of Galls per plant	Root-knot Index	Population of Nematode		Total population	Intensity of powdery Mildew
						Root population /5g.	Soil population /250g		
10	38.5	4.8	1.7	10	0.5	32	200	232	1
20	47.0	5.3	1.9	14	0.7	50	265	315	2
30	58.7	6.9	2.3	39	2.0	100	415	515	2
40	54.9	6.0	2.1	47	2.4	138	450	588	3
50	50.0	5.7	2.0	30	1.5	80	378	458	3
L.S.D. at 5%	5.17	.53	.30	4.85	.43	19.50	65.71	70.46	

Each figure is the replicate of four plants.

Table - 26

Effect of different moisture levels on the development of root knot nematode *M. incognita* and intensity of powdery mildew *S. fuliginea* in *Cucumis sativus*.

Treatments at different moisture levels	Total length of Plant (cm)	Fresh weight of Plant (gm)	Dry weight of Plant (gm)	No.of Galls per Plant	Root knot Index	Population of Nematode		Total Population	Intensity of Powdery mildew
						Root population /5g. Root	Soil Population /250 g. Soil		
10	30.3	4.4	1.6	12	0.6	25	165	190	1
20	36.0	5.8	2.0	17	0.8	47	220	267	2
30	54.5	7.9	2.9	38	1.9	90	407	497	2
40	50.0	7.2	2.7	45	2.2	115	436	551	3
50	47.5	6.7	2.4	30	1.5	72	338	408	3
L.S.D. at 5%	4.68	.61	.39	5.14	.37	20.63	57.09	67.45	

Each figure is the replicate of four plants.

Fig. 13. Effect of inoculating Lagenaria leucantha with Sphaerotheca fuliginea and root knot nematode Meloidogyne incognita at different soil moisture levels on the growth of plant and the population of the nematode.

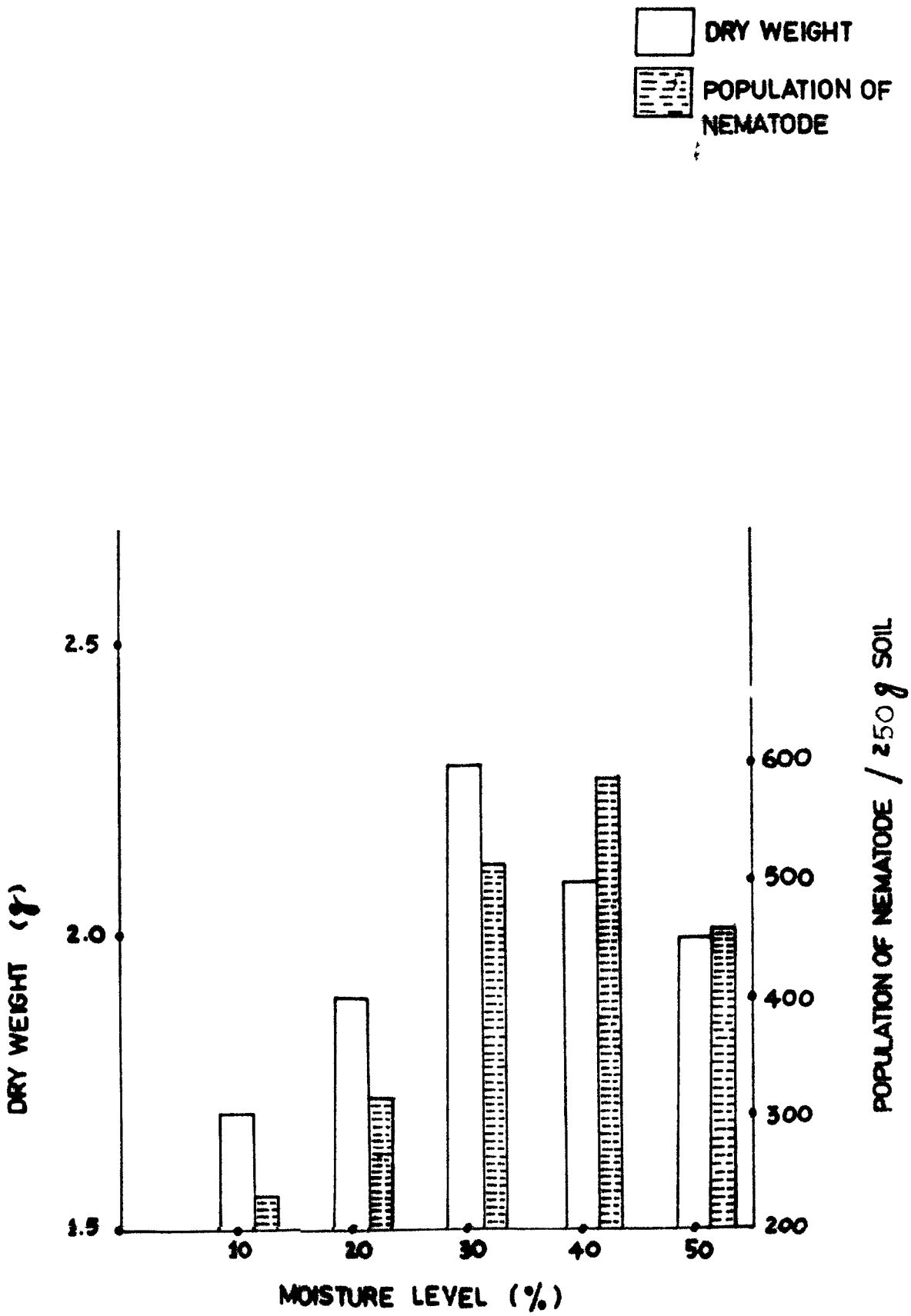

DRY WEIGHT
POPULATION OF NEMATODE
DRY WEIGHT (g)
2.5
2.0
1.5
POPULATION OF NEMATODE / 250 g SOIL
600
500
400
300
200
10
20
30
40
50
MOISTURE LEVEL (%)

FIG. 13

Table - 27

Effect of different moisture levels on the morphometrics of the female of nematode *M. incognita* in *L. leucantha*.

Treatments at different Moisture levels (%)	Body length (µm)	Body width (µm)	Neck length (µm)	Neck width (µm)	Median bulb length (µm)	Median bulb width (µm)
10	450.0-490.0	285.5-310.0	160.0-195.0	80.0-135.0	30.5-36.7	31.0-35.0
	465.7±16.17 (3.47)	300.0±10.28 (3.42)	180.3±16.73 (9.27)	95.2±17.92 (18.82)	33.4±2.77 (8.29)	33.0±1.88 (5.69)
20	450.0-530.0	300.0-345.0	190.5-275.0	85.0-165.0	33.0-38.0	35.0-37.5
	490.5±20.47 (4.17)	321.5±11.68 (3.63)	238.8±37.13 (15.54)	122.0±30.4 (24.91)	36.5±1.65 (4.52)	36.0±1.08 (3.0)
30	600.0-715.0	365.0-480.0	290.0-400.0	115.0-205.0	38.0-42.0	37.0-41.7
	667.0±40.34 (6.05)	427.0±46.93 (10.99)	328.5±41.63 (12.67)	154.0±36.65 (23.79)	40.6±1.75 (4.31)	39.5±1.41 (3.57)
40	600.0-700.0	350.0-468.0	290.0-365.0	115.0-190.0	38.0-41.5	37.0-41.0
	646.5±49.67 (7.68)	419.5±46.49 (11.08)	317.9±36.14 (11.37)	151.6±30.73 (20.27)	39.6±1.78 (4.49)	39.2±1.33 (3.39)
50	510.0-600.0	300.0-440.0	215.0-300.0	115.0-175.0	37.0-40.0	36.2-40.0
	517±19.37 (3.74)	383.7±37.30 (9.72)	286.5±34.68 (12.10)	140.5±18.98 (13.50)	37.9±1.91 (5.03)	37.6±1.05 (2.79)
L.S.D. at 5% level	19.26	23.96	15.02	14.17	3.95	2.19

Each figure is the replicate of twenty females.
Figure in parenthesis indicate CV.

Table - 28

Effect of different moisture levels on the morphometrics of the females of nematode *M. incognita* in *Cucumis sativus*.

Treatments at different moisture levels (%)	Body length (µm)	Body width (µm)	Neck length (µm)	Neck width (µm)	Median bulb length (µm)	Median bulb width (µm)
10	315.0-450.0	215.0-300.0	150.0-225.0	60.0-140.0	32.5-38.5	30.0-34.5
	407.8±41.13 (10.08)	257.0±30.15 (11.73)	181.5±26.81 (14.77)	91.0±24.87 (24.03)	36.1±2.16 (5.98)	33.3±2.06 (6.18)
20	395.0-495.0	250.0-325.0	180.0-250.0	80.0-155.0	35.0-38.5	33.5-36.7
	458.7±37.18 (8.10)	290.5±26.88 (9.25)	207.5±25.91 (12.48)	110.7±30.85 (27.86)	36.9±4.13 (11.19)	34.8±1.53 (4.39)
30	545.0-705.0	335.0-465.5	275.0-380.0	95.0-200.0	39.0-43.0	38.0-40.5
	622.7±60.17 (9.66)	393.7±57.12 (14.50)	299.0±40.19 (13.44)	138.0±38.79 (28.10)	42.1±2.91 (6.91)	39.3±1.85 (4.70)
40	490.0-665.0	325.0-450.0	275.0-380.0	95.0-190.0	39.0-42.5	38.8-1.77
	578.5±58.39 (10.09)	383.5±51.67 (13.47)	299.5±44.60 (15.14)	132.6±30.72 (23.16)	41.3±1.98 (4.79)	38.8±1.77 (4.56)
50	440.0-585.0	300.0-400.0	210.0-320.0	95.0-190.0	38.0-41.0	38.0-40.0
	501.5±49.07 (9.78)	368.2±46.17 (12.53)	281.7±41.42 (14.70)	129.5±27.89 (21.53)	40.8±1.95 (4.77)	38.1±1.62 (4.25)
L.S.D. at 5% level	23.16	17.83	16.42	9.39	1.47	1.89

Each figure is the replicate of twenty females.

Figure in parenthesis indicate CV.

By and large as in previous studies, the morphometrics values of females of root-knot were low where the root-knot index was low. The highest values of various morphometric characters were obtained at 30 percent moisture levels and lowest at 10 percent moisture levels in the both the plants (Table 27 & 28).

EFFECT OF INOCULATING THE SEEDLINGS OF L. LEUCANTHA GROWN IN SOIL FERTILIZED WITH DIFFERENT DOSES OF N & K FERTILIZERS, WITH M. INCOGNITA AND S. FULIGINEA ON GROWTH OF PLANTS AND ROOT-KNOT DEVELOPMENT.

It is clear from the table 29 that when plants inoculated with root-knot nematode and powdery mildew were grown in soil fertilized with different doses of fertilizers (Sub-optimal, optimal & double), the growth of inoculated plants increased with the increase in the dose of NK fertilizers, highest growth being observed in plants supplied with optimal dose of fertilizers. This increase was more than in those plants in which nitrogen and potassium fertilizers were supplied separately. When the plants were supplied with double dose of NK fertilizers, the growth of plants was more in N alone and the root-knot index was more in those grown in K fertilizer. Similarly, the population of nematode was high

in K fertilizer alone followed by N. The root-knot index was highest in those grown with optimal dose of NK fertilizers followed by sub-optimal and double dose. Highest population of nematode was observed in the optimal dose(Fig. 14).

The intensity of powdery mildew was highest in those plants grown in Nitrogen alone, very poor in those supplied with double dose of NK fertilizers. It is therefore, observed that nitrogen fertilizers favoured the growth of plants and the development of powdery mildew while potassium favoured the development of nematode (Table 29).

Results presented in table 31 show that when the morphometric characters of the females of the nematode were studied, the measurements of body length, body width, neck length, neck width, median bulb length and median bulb width were significantly higher in K fertilizer followed by N fertilizer. With different doses of NK fertilizers, the root-knot index increased with the increase in dose from sub-optimal to optimal, but at double dose it decreased. The highest multiplication was observed in optimal dose of the fertilizers. It is therefore, observed that double dose of NK fertilizers no doubt enhanced the plant growth in comparison to those supplied with N & K seperately and sub-optimal dose but brought about the reduction in population of nematode and morphometric characters of the females.

Similarly, measurements of body length, width; neck length, width; median bulb length, width significantly increased in optimal dose of NK fertilizers as compared to double dose (Table 31).

It is evident that potassium fertilizers not only increased the multiplication of the nematode but resulted in higher values of measurements of various characters as compared to N.

It is clear from the table 31, that in plants inoculated with both powdery mildew and nematode, the measurements of body length, width; neck length, width; median bulb length and width were significantly reduced in comparison to those (Table 31) which inoculated with nematode alone. There was no marked reduction in the measurements of various characters in those supplied with double dose of N K fertilizers due to poor development of powdery mildew. It is therefore, observed that presence of powdery mildew reduced the size of females of the nematode (Table 32).

EFFECT OF INOCULATING THE SEEDLINGS OF L. LEUCANTHA AND C. SATIVUS GROWN IN UNAUTOCLAVED AND AUTOCLAVED SOIL WITH POWDERY MILDEW, ROOT-KNOT NEMATODE AND FUNGUS-NEMATODE BOTH ON GROWTH OF PLANTS, ROOT-KNOT DEVELOPMENT AND RHIZOSPHERE MYCOFLORA.

Results presented in table 33 show that reduction in growth of L. leucantha and C. sativus as a result of

Table - 29

Effect of inoculating the seedlings of L. leucantha, grown in soil fertilized with different doses of NK, with single eggmass population of M. incognita and pure culture of fungus S. fuliginea on growth of plants and root knot development.

Treatments	Total dry weight of plants (gm)	No. of Galls/ plant	No. of eggmasses/ plant	Root-knot Index	Population of Nematode		Total population of Nematodes	Intensity of Powdery mildew
					Soil population /250g Soil	Root population /5g. Root		
Nitrogen only								
Uninoculated	2.7	-	-	-	-	-	-	-
Inoculated	2.5	50	68	3.0	220	150	370	3
Potassium only								
Uninoculated	2.6	-	-	-	-	-	-	-
Inoculated	2.3	78	94	4.0	345	250	595	2
NK (Sub optimal dose)								
Uninoculated	2.8	-	-	-	-	-	-	-
Inoculated	2.5	75	97	4.0	380	285	665	2
NK (Optimal dose)								
Uninoculated	3.0	-	-	-	-	-	-	-
Inoculated	2.6	87	105	5.0	445	315	760	2
NK (Double dose)								
Uninoculated	2.9	-	-	-	-	-	-	-
Inoculated	2.8	40	52	2.0	180	110	290	1
L.S.D. at 5% level	.17	11.58	12.20	.58	42.84	46.45	61.07	0

Each value of an average of five replicates.

Fig. 14. Effect of fertilizers on the development of powdery mildew S. fuliginea on Lagenaria leucantha.

1. Resistant (NK double dose)
2. Moderately resistant (K only, NK suboptimal & NK optimal dose).
3. Susceptible (Nitrogen only)
4. Highly susceptible (Without any fertilizer).

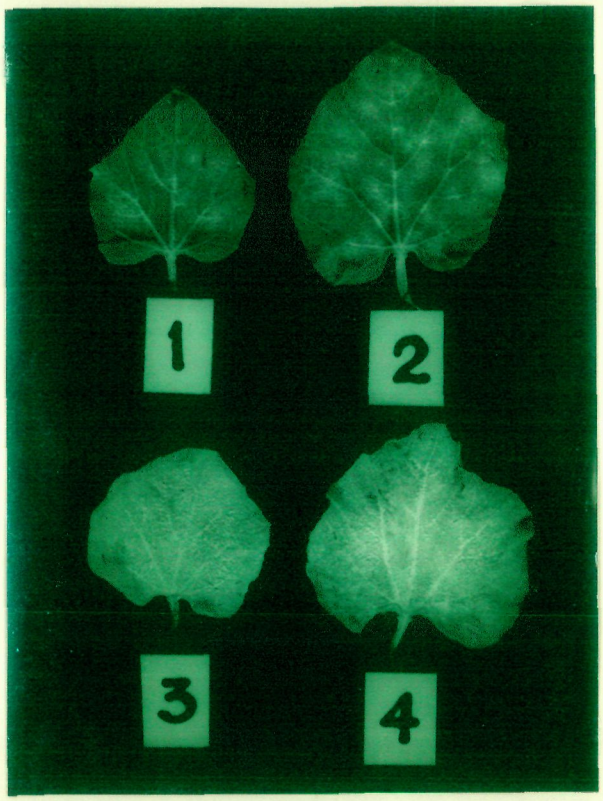


FIG. 14.

Fig. 14. Effect of inoculating Lagenaria leucantha with Sphaerotheca fuliginea and Meloidogyne incognita at different doses of fertilizers on the growth of plant and the population of the nematode.

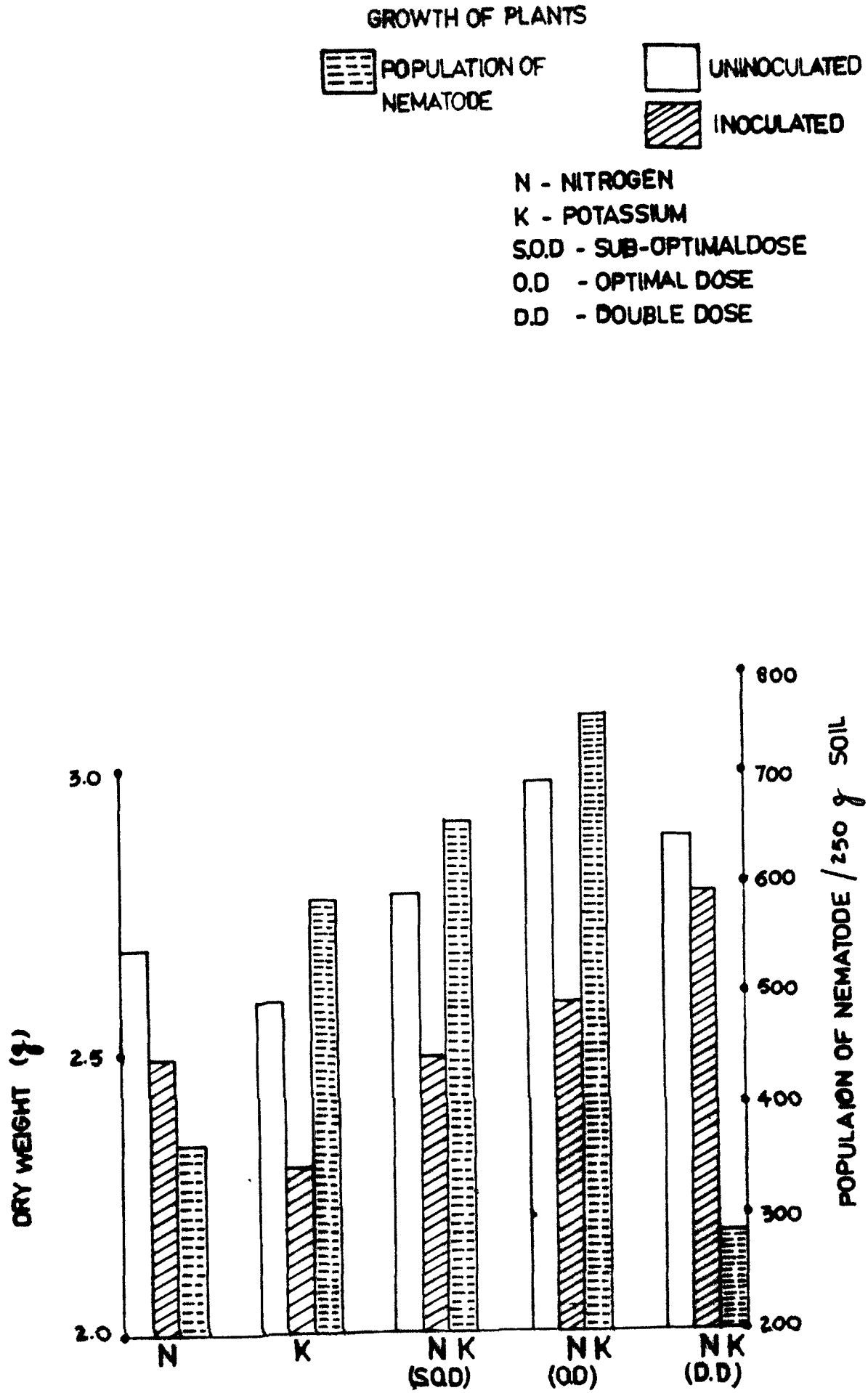

GROWTH OF PLANTS
POPULATION OF NEMATODE
UNINOCULATED
INOCULATED
N - NITROGEN
K - POTASSIUM
S.O.D - SUB-OPTIMALDOSE
O.D - OPTIMAL DOSE
D.D - DOUBLE DOSE
DRY WEIGHT (g.)
3.0
2.5
2.0
800
700
600
500
400
300
200
POPULATION OF NEMATODE / 250 g SOIL
N
K
N K (S.O.D)
N K (O.D)
N K (D.D)

FIG. 14.

Table - 30

Measurement of the original population of *M. incognita* raised from single egg mass and taken from infected roots of *Lagenaria leucantha*.

Characters	Range (µm)	Mean (µm)	S.D	C.V	L.S.D. at 5% level
Body length	500.0-865.0	610.25	109.25	17.90	10.14
Body width	335.0-510.0	409.50	51.88	12.67	13.67
Neck length	200.0-395.0	279.50	71.79	25.68	14.91
Neck width	70.5-165.0	112.10	30.74	27.42	9.07
Median bulb length	40.0-52.5	46.0	3.76	8.17	3.88
Median bulb width	39.2-50.0	43.5	3.83	8.80	2.89

Each figure is the replicate of twenty females.

Table - 31

Effect of N & K fertilizers on the morphometrics of females of *M. incognita* in *Lagenaria leucantha*

Treatment characters	Nitrogen only				Potassium only				N & K (Sub-optimal)dose			
	Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.
Body length	535.0-700.0	615.50	90.30	14.67	585.0-740.0	671.5	71.72	10.68	580.0-7750	679.93	74.69	10.98
Body width	380.0-500.0	446.5	45.50	10.11	400.0-515.0	452.5	43.28	9.56	405.0-520.0	461.5	39.61	8.58
Neck length	200.0-370.0	281.50	62.29	23.02	230.0-400.0	320.0	54.72	17.10	247.5-420.0	335.50	60.09	17.91
Neck width	90.0-175.0	119.70	27.39	23.27	95.0-175.0	121.90	27.03	22.73	100.0-170.0	125.00	29.64	25.18
Median bulb length	40.0-50.0	44.22	3.75	8.90	43.0-52.5	48.14	3.63	7.55	42.5-50.0	45.72	4.13	9.03
Median bulb width	38.0-47.5	41.70	3.13	7.50	41.7-49.0	45.27	2.60	5.75	40.0-49.0	43.81	3.41	7.78

Each figure is replicate of twenty females.

contd...

Table 31 (contd..)

N & K (optimal dose)				N & K (Double dose)				L.S.D. at 5% level
Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.	
600.0-800.5	704.0	71.10	10.08	495.0-650.0	585.5	97.89	16.71	15.09
405.0-540.5	468.5	46.90	10.01	325.0-495.0	400.12	60.09	15.01	10.54
265.5-415.0	338.0	52.71	15.59	175.0-310.5	253.51	73.66	29.05	4.13
85.0-165.0	126.6	27.85	21.99	90.0-175.0	117.5	33.61	29.23	6.71
43.0-53.5	49.3	3.78	7.84	40.0-50.0	44.03	4.25	9.65	1.27
43.0-50.0	47.25	2.73	5.93	38.0-45.0	40.15	3.90	9.71	1.65

Table - 32

Effect of N & K fertilizers and powdery mildew fungus, S. fuliginea on the morphometrics of females of M. incognita in in Lagenaria leucantha.

Treatments characters	Nitrogen only				Potassium only				N & K (Sub-optimal dose)			
	Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.
Body length	500.0-750.0	600.35	81.45	13.56	560.5-715.0	639.7	79.18	12.37	545.7-742.0	650.6	73.14	11.24
Body width	350.0-500.0	417.5	49.63	11.89	380.0-500.0	415.5	45.05	10.84	390.0-500.0	428.3	45.98	10.74
Neck length	200.0-345.0	277.3	67.15	24.21	200.0-395.0	307.5	60.58	19.70	215.5-390.0	319.6	56.47	17.66
Neck width	75.0-165.0	115.0	30.25	26.30	90.0-175.0	117.9	28.93	24.53	90.0-175.0	129.7	29.0	22.35
Median bulb length	40.0-47.5	44.5	3.80	8.54	40.0-50.0	45.5	4.17	9.14	41.5-52.0	47.5	4.03	8.48
Median bulb width	38.5-45.0	40.6	3.65	8.99	38.0-47.0	43.7	3.23	7.39	38.0-49.5	45.3	3.17	6.99

Each figure is replicate of twenty females.

contd....

Table 32 (contd..)

N & K (optimal dose)				N & K (Double dose)				L.S.D. at 5% level
Range (µm)	Mean (µm)	S.D.	C.V.	Range (µm)	Mean (µm)	S.D.	C.V.	
600.0-800.0	678.7	70.32	10.36	500.0-660.0	579.0	92.17	15.91	13.97
400.0-550.0	459.0	45.74	9.96	315.5-485.0	393.2	58.32	14.83	10.03
225.5-435.0	340.5	51.93	15.25	190.0-300.0	245.6	76.09	30.98	4.17
90.0-165.0	117.5	27.03	23.0	75.5-170.0	118.7	31.36	26.41	5.79
43.0-52.0	48.70	3.92	8.04	39.0-45.5	42.9	4.27	9.95	1.59
40.0-50.0	46.50	2.70	5.80	37.0-43.7	39.72	3.86	9.71	1.82

inoculation with nematode and fungus both was more when grown in unautoclaved soil than in autoclaved soil. On the other hand, root knot index was more in those plants grown in autoclaved soil. The population of nematode and intensity of powdery mildew was also more in autoclaved soil than in unautoclaved soil.

It is clear from the table 34, that by and large, the measurements of females was more in those reared in autoclaved soil. It indicates that bigger females were developed in autoclaved soil in comparison to unautoclaved soil. The values of body length, body width, neck length, neck width, median bulb length and median bulb width were significantly increased in autoclaved soil.

Table 35 shows that in L. leucantha, out of 21 fungi, 11 were recovered from the rhizosphere of plants inoculated with powdery mildew, 13 fungi from inoculated with nematode, and 17 fungi were recovered from the rhizosphere of plants inoculated with fungus and nematode both and only 8 from uninoculated plants grown in unautoclaved soil. Similarly in C. sativus, out of 20 fungi, 12 were recovered from the rhizosphere of plants inoculated with powdery mildew, 12 from nematode inoculated plants, 16 from fungus and nematode inoculated plants and 9 from uninoculated plants grown in

unautoclaved soil. In rhizosphere of C. sativus, Aspergillus terreus and Trichoderma album were absent and in L. leucantha, Sclerotium rolfsii was absent while remaining fungi were common in both plants.

In the rhizosphere of L. leucantha grown in unautoclaved soil, Aspergillus flavus, A. niger, Fusarium spp. and Rhizopus nigricans were isolated from all the treatments, and in C. sativus, A. candidus, A. niger, curvularia pallescens and R. nigricans were recovered from all the treatments.

The rhizosphere mycoflora of seedlings grown in autoclaved soil was some what different (Table - 36). In L. leucantha, out of 8 fungi, 4 were recovered from the rhizosphere of plants inoculated with fungus, 5 from nematode inoculated plants, 6 from fungus nematode inoculated plants and only 3 fungi from uninoculated plants. In rhizosphere of C. sativus only six fungi were recovered as against of twenty in naturally infested soil. Out of 6 fungi, 3 were recovered from fungus inoculated plants, 5 from nematode inoculated and other 5 fungi from fungus and nematode inoculated plants. Only 2 fungi were recovered from uninoculated plants. In rhizosphere of L. leucantha, A. niger, A. flavus & R. nigricans and in C. sativus, A. niger and R. nigricans were isolated in all the treatments.

It is clear from the tables 35 and 36 that both the number and frequency of fungi were higher in the rhizosphere of L. leucantha and C. sativus grown in unautoclaved soil in comparison to autoclaved soil.

Table - 33

Effect of inoculating the seedlings of *Lagenaria leucantha* and *Cucumis sativus* grown in unautoclaved and autoclaved soil with single egg mass population of nematode *M. incognita* and powdery mildew fungus *S. fuliginea* on growth of plants and root knot development and intensity of powdery mildew.

Host/Treatments	Total dry weight of plants(hm)	No. of Galls/ plant	No. of eggmass/ plant	Root-knot index	Population of Nematode In soil /250 g.	Population of Nematode In Root /5 g.	Total population	Intensity of powdery mildew
Lagenaria leucantha								
Unautoclaved soil								
Uninoculated	2.3	-	-	-	-	-	-	-
Inoculated	2.1	59	67	3.00	482	165	647	3
Autoclaved soil								
Uninoculated	2.8	-	-	-	-	-	-	-
Inoculated	2.5	90	100	5.00	790	257	1047	4
L.S.D. at 5% level	0.29	10.71	7.45	0.45	58.54	25.34	116.92	
Cucumis sativus								
Unautoclaved soil								
Uninoculated	2.7	-	-	-	-	-	-	-
Inoculated	2.4	50	57	3.00	517	143	660	3
Autoclaved Soil								
Uninoculated	3.2	-	-	-	-	-	-	-
Inoculated	2.9	79	75	4.00	725	230	955	4
L.S.D. at 5% level	0.28	9.83	7.69	.38	53.79	27.03	109.83	

Each value is an average of five replicates.

Table - 34

Effect of inoculating plants grown in unautoclaved and autoclaved soil with powdery mildew fungus *S. fuliginea* and single egg mass population of *M. incognita* on the morphometrics of females.

Host characters	Statistical parameter	*Lagenaria leucantha*					*Cucumis sativus*				
		Range (µm)	Mean (µm)	S.D.	C.V.	L.S.D. at 5%	Range (µm)	Mean (µm)	S.D.	C.V.	L.S.D. at 5%
Measurements of females											
Body length	Unautoclaved	427.5-695.0	528.9	98.52	18.62		400.0-650.0	539.50	84.10	15.58	
	Autoclaved	480.0-755.0	604.2	105.02	17.38	21.16	490.0-710.0	601.75	80.17	13.32	17.69
Body width	Unautoclaved	245.0-415.5	354.6	60.30	17.00		268.5-410.0	330.65	50.13	15.16	
	Autoclaved	315.50-450.0	398.2	46.97	11.79	11.04	300.0-465.5	383.72	47.66	12.42	11.43
Neck length	Unautoclaved	180.0-310.0	239.15	43.53	18.20		185.0-337.5	243.6	50.14	20.58	
	Autoclaved	200.0-375.0	290.72	63.13	21.71	15.79	200.0-350.0	288.5	50.77	17.59	9.83
Neck width	Unautoclaved	75.0-130.0	114.65	24.36	21.24		65.0-125.0	110.9	20.04	18.07	
	Autoclaved	95.0-150.0	132.25	23.61	17.85	5.38	90.0-145.5	130.0	20.16	15.50	6.01
Median bulb length	Unautoclaved	35.50-50.0	40.95	4.01	9.79		36.0-50.0	42.0	4.06	9.66	
	Autoclaved	41.75-52.0	46.0	3.43	7.15	1.78	40.0-50.0	45.7	3.23	7.06	1.56
Median bulb width	Unautoclaved	35.0-40.0	37.7	2.05	5.43		35.0-42.5	39.7	2.46	6.19	
	Autoclaved	39.50-48.0	44.4	3.32	7.47	2.11	40.0-47.5	42.5	2.15	5.05	1.96

Each figure is the mean of twenty females.

Table - 35

Frequency of Rhizosphere mycoflora of uninoculated and inoculated plants of Lagenaria leucantha and Cucumis sativus grown in unautoclaved soil.

	Frequency percentage							
		Lagenaria leucantha Inoculated with				Cucumis sativus Inoculated with		
	Uninoculated Plants	Powdery mildew	Nematode	Powdery mildew and Nematode	Uninoculated Plant	Powdery mildew	Nematode	Powdery mildew and Nematode
1. Alternaria humicola Chaudhuri	-	-	20	20	-	-	10	20
2. Aspergillus candidus Link	-	20	20	30	10	20	20	20
3. A. clavatus Desmazieres	-	-	-	20	20	-	-	-
4. A. flavus Link	20	25	50	50	30	60	40	25
5. A. niger vantieghem	20	40	60	60	-	20	50	60
6. A. fumigatus Fresenius	-	40	-	-	-	50	40	45
7. A. terreus thom.	-	30	-	-	-	-	-	-
8. Chaetomium spp. Kunze & Schmidt	40	80	-	20	30	60	-	-
9. Cladosporium herbarum Link	-	-	20	20	-	-	-	20
10. Curvularia pallescens	-	-	40	40	10	20	20	40
11. C. lunata (Walker) Boedijn	20	-	-	-	10	-	20	20
12. Cunninghamella verticillata Paine	80	-	-	-	90	-	-	25
13. Fusarium spp. Link.	20	20	30	20	-	20	40	30
14. Helminthosporium nodulosum Saccardo	-	-	20	25	-	-	-	20
15. Mortierella alpina Peyroud	30	70	-	10	40	50	-	-
16. Mucor spp. Micheli	-	10	40	25	-	20	20	30
17. Penicillium chrysogenum	-	20	10	20	-	20	-	-
18. Rhizopus nigricans Ehrenberg	20	40	60	30	-	40	80	50
19. R. oryzae Went & Gerlings	-	-	40	40	20	10	30	30
20. Rhizoctonia solani Kuhn	-	-	20	10	-	-	20	20
21. Sclerotium rolfsii Saccardo	-	-	-	-	-	-	-	20
22. Trichoderma album Preurs.	-	-	-	20	-	-	-	-

Date based on average of ten replicates.

Table - 36

Frequency of rhizosphere mycoflora of uninoculated and Inoculated plants of *Lagenaria leucantha* and *Cucumis sativus* grown in autoclaved soil.

Fungi Isolated	Frequency percentage							
	Lagenaria leucantha				*Cucumis sativus*			
		Inoculated with				Inoculated with		
	Uninoculated Plants	Powdery mildew	Nematode	Powdery mildew and Nematode	Uninoculated Plant	Powdery mildew	Nematode	Powdery mildew and Nematode
1. *A. niger*	30	30	20	40	40	20	40	50
2. *A. flavus*	20	40	40	30	-	40	20	20
3. *Curvularia pallescens*	-	-	20	-	-	-	-	20
4. *Fusarium* spp.	-	-	-	20	-	-	-	-
5. *Mucor* spp.	-	-	20	20	-	-	30	20
6. *Mortierella alpina*	-	20	-	-	-	-	-	-
7. *Penicillium chrysogenum*	-	-	-	20	-	-	20	-
8. *Rhizopus nigricans*	20	30	40	30	30	30	20	40

CHAPTER - V

D I S C U S S I O N

Powdery mildews have been known to take a heavy toll of various crops every year throughout the world. This is more true with India where little work has been carried out. In view of these facts, in the present investigation an attempt has been made to identify the powdery mildew and to assess the extent of losses caused by them, on the members of the family Compositae and Umbelliferae. Although considerable work has been carried out on various aspects of cucurbit powdery mildews both in India and elsewhere (Vasudeva, 1960; Jhooty, 1967; Khan et al., 1970, 1971; Mathur et. al. 1971; Kapoor, 1967; Nour, 1957; Clare, 1958; Kable and Ballantyne, 1963 and Blumer, 1933, 1967) but nothing is known as to the development of powdery mildew when the cucurbit plants are under various kinds of stress. It is with the aim in view the present investigations were undertaken.

During the survey, the powdery mildew of composits appears in two flushes one from January to March and other from October to December (Table I). However, powdery mildew of umbelliferous plants occurred only during late January to early May (Table 2.). It is understandable that during these periods both temperature and relative humidity are moderate

and highly favourable for the development of the disease as reported by Levykh (1940), Minev (1957), Rossuw (1959), Schnathorst (1960), Morrison (1961 & 1964), Malik et al. (1973), Khan (1975) and Chen & Chen (1981). However, no infection on composits has been observed from April to September (Table 1) probably because the temperature remains very high and relative humidity is also very low. Similar seasonal fluctuations in disease development has been found by Levykh (1940), Deslandes (1954), Minev (1957), RossouW (1959) and Schnathorst (1960).

Although attempts were made to search for perfect stages on the diseased plants, but in most cases it was not possible. Therefore, identification in such cases is based on various conidial characters as suggested by Hirata (1942), Nour (1957), Clare (1958), Kable and Ballantyne (1963), Zaracovites (1965), Blumer (1967), Kapoor (1967), Jhooty (1967), Mathur et al. (1971 & 1974). Thus powdery mildew of compositae is identified as Erysiphe cichoracearum (Table 3). This is in conformity with the finding of Tarr (1952), Nour (1957), Boerema and Vankesteren (1964), Zaracovitis (1965), Blumer (1967), Kapoor (1967) Pavgi and Upadhyay (1966) and Jain and Singh (1968). On the other hand, Patil (1964), Patwardhan, (1965), Jhooty (1965), Hirata (1966), Prasada et al. (1968) and Srivastava and Rawat (1982) reported S. fuliginea; Kamat and Patil (1948),

Jain and Singh (1968), Desai et al. (1970) and Mathur et al. (1971), L. taurica; and Deshpande and Dake (1978) and Grigalyunaite and Shpokauskene (1981) Oidium spp. on different members of fam. Compositae.

Powdery mildew on umbelliferous hosts has been identified as E. heraclei again based on hyphal and conidial characters. Noviello (1961), Borema et al. (1963), Hirata (1966), Kapoor (1967), Blumer (1967), Noble and Richardson (1968), Ferri (1969), Geary and Wall (1976), Abiko (1976), Gupta et al. (1982) and Ryan et al. (1983) also reported E. heraclei on these hosts; but Uppal and Desai (1933), Anonymous (1950, 1957), Nour (1959), Chona et al. (1960), Gupta and Dalela (1962), Khan and Kamal (1962), Chorin and Parli (1962) Desai et al. (1970), Srivastava et al. (1971), Prasada et al. (1971), Mathur et al. (1974), Abercrombie and Harry (1976) and Wu (1977) reported other powder mildew pathogens on different members of the fam. Umbelliferae. The differences in the identifications made here with those reported by others earlier can be accounted to be due to more than one powdery mildew fungus infecting these hosts and they may be differing in distribution depending upon different climatic conditions. The identification of E. heraclei, on umbelliferous hosts has been confirmed when cleisthothecia

have been observed in nature on D. carota during late season of the crop. The measurements of different characters of the cleistothecia (Table 4) were in agreement with those of Blumer (1967) and Kapoor (1967), thereby confirming that D. carota is infected with E. heraclei.

Results on host range studies indicate that isolates of E. cichoracearum from X. strumarium, H. annuus and D. variabilis infect Cosmos spp., D. variabilis, Z. elegans and H. annuus among the cultivated composits and X. strumarium and S. oleraceous among the wild composits (Table 5). However, Ch. carinatum, Cl. officinalis and Aster spp. have been found to be resistant to these isolates. E. cichoracearum as found on composits appears to be different from the one that infects cucurbits as repeated attempts to infect members of Compositae with that on cucurbits have failed (Table 6). Similar differences in the pathogenicity among the various isolates of powdery mildews have been reported by Miller and Barrett (1931), Schmitt (1955) and Schnathorst et. al. (1958).

D. carota, C. sativum, and A. graveolens appear to be hosts of all the three isolates, while, F. vulgare, of isolates from C. sativum and A. graveolens and Cu. cyminum of only C. sativum (Table 7). This indicates that some kind of specialisation exists but more studies are required to conclude

that there are distinct biological races. Biological specialization in powdery mildew fungi is not uncommon as it has been reported in many powdery mildews (Miller and Barrett, 1931; Schmitt, 1955; Schnathorst, 1958).

In majority of the tests the host response to powdery mildew in glass house and field has been the same. However, varieties of H. annuus, Z. elegans and Dahlia spp. have been found susceptible in glass house but susceptible to moderately resistant in the field (Table 9,10,11) when screened against the two composit isolates of E. cichoracearum viz. from H. annuus and Z. elegans. This is understandable as in the glass house the conditions are a bit controlled and this become more conductive for the development of powdery mildew but in the field there are many other uncontrollable factors which influence the development of the disease (Delp, 1954; Mansson, 1955; Yarwood, 1957; Cole, 1964 and 1966; Schnathorst, 1965). This further suggested with respect to studies on various varieties of D. carota cultivars, pusa kesar, tender sweet, Danvers half long and Nantes early long have been found highly susceptible in glass house but moderately susceptible in field (Table 12) when screened against two isolates of E. heraclei viz D. carota and C. sativum.

On the basis of the present investigations it appears that different isolates of E. heraclei can be differentiated by using F. vulgare, Cu. cyminum and Ca. copticum as hosts. These are summarised below. D. carota isolate is characterised to infect D. carota but does not infact F. vulgare and Cu. cyminum, C. sativum isolate infect D. carota, Cu. cyminum and F. vulgare; while A. graveolens isolate infect F. vulgare only (Table 7).

	HOSTS					
ISOLATES	D.carota	C.sativum	A.graveolens	Ca.copticum	Cu.cyminum	F.vulgare
D.carota	+	+	+	-	-	-
C.sativum	+	+	+	-	+	+
A.graveolens	+	+	+	-	-	+

Isolates of E. polygoni from Pisum sativum, Cassia occidentalis and Chenopodium ambrosoides, however, failed to infect any of the umbelliferous hosts tested (Table 8). Thus identification made in the present slides is not in confirmity with the identification of powdery mildew as E. polygoni on

umbelliferous hosts (Salmon, 1900; Uppal and Desai; 1933; Anonymous, 1950; Arya, 1957; Chona et al., 1960; Gupta and Dalela, 1962; Vasudeva, 1963 and Srivastava et al. (1971). It is likely that in those localities a different race of E. polygoni other than on P. sativum might be infecting the umbelliferae plants because of different environmental conditions.

Studies on the effect of temperature and relative humidity (Tables 13, 14, 15 & 16) show that the temperatures below 10° or above 30° and relative humidity below 80 percent do not favour the germination of conidia. The result on the effect of temperatures and relative humidity on the germination of the conidia of E. cichoracearum and E. heraclei are not very different from those reported by Levykh (1940), Deslandes (1954), Minev (1957), Rossouw (1959), Schnathorst (1960), Morrison (1961, 1964), Tafradzhiiski (1963) and Chen & Chen (1981) as the germination occurs at a wide range of temperatures with optimum temperature as 17 - 20°C for E. cichoracearum, 20-28°C for E. heraclei and wide range of relative humidity with 95-100 percent as optimum for both. Further, free water has retarted the germination and thus confirm the findings of Corner (1935), Minev (1957), Schnathorst (1959), Morrison (1961, 1964) and Tafradzhiiski (1963).

Similarly the development of powdery mildew has been highest at 20°C and 90% relative humidity. At other temperatures

and relative humidities the development of powdery mildews has been poor. This shows a moderate cool and moderate moisture favour the disease development. This is probably the reason of high incidence during October to late November and late January to March. Similar results have been obtained by Morrison (1961 & 1964). Symptoms develop within 5 days at optimal temperature irrespective of the relative humidity (Table 17). Thus the relative humidity does not appear to exert much influence on the development of disease at optimal temperature. However, at temperatures above or below the optimum relative humidity appear to have some effect. Deslandes (1954), Minev (1957), Rossouw (1959) Schnathorst (1960) and Morrison (1961 & 1964) observed highest infection at moderate temperature and moderate relative humidity.

On the basis of information available from different parts of the world, powdery mildew of cucurbits seems to be largely caused either by S. fuliginea or E. cichoracearum. In the present studies dealing with this aspect, Cucumis sativus (cucumber) has been found a common host to both E. cichoracearum and S. fuliginea (Table 18). Both the pathogens developed equally on leaves of the host plant. These studies are in a way in agreement with the findings of Huttenbach (1951), Blumer (1967), Rudenko (1968) and Nomura (1974).

In nature plants are subjected to various stresses — physical and biotic stress which might influence the development of powdery mildew. Moreover it has been reported that plants become susceptible to diseases when under stress (Yarwood, 1959). Therefore, the development of powdery mildew has been determined when plants have been subjected to various stresses viz, infection in roots with root-knot nematode, excess and deficiency of fertilizers and soil moisture.

By and large, members of fam. Compositae are known for resistance against root-knot nematode (Hijink and Winoto,1967). Therefore, an attempt was made to determine their susceptibility to the nematode at the first instance. Dahlia variabilis has been found very susceptible to root-knot nematode, as well as to powdery mildew. Therefore, it has been selected in amongst the composits for stress studies. In addition to this Cineraria spp. and Calendula officinalis also exhibit varying degree of susceptibility to root-knot nematode. On the other hand, Chyranthemum carinatum, Helianthus annuus and Zinnia elegans have been found resistant to root-knot nematode (Table 19). In Cosmos sulphurus, there has been penetration of larvae but none of the larvae have been found to metamorphose in to mature females. These nonhosts of composits for root-knot nematode could in part be due to nematoxic principles present there in (Uhlenbrock and Bijloo, 1960).

The severity of powdery mildews has been high in the plants inoculated with root knot nematode and plants succumb to death earlier as compared to those inoculated with powdery mildew alone. This is understandable partly as nematode infection causes deficiency of elements more particularly potassium (Oteifa, 1952, 1953) in plants, and potassium deficiency has been known to increase the susceptibility to powdery mildew (Cole 1964, 1966); and partly because nematode infected plants have greater quantity of carbohydrates (Wang and Bergeson 1974) favouring the development of powdery mildew (Yarwood, 1934). These results in a way support the findings of Faulkner & Skotland (1965), Conroy et al. (1972) & Porter and Powell (1967) who report increase in severity of fungus disease due to interaction between fungi and nematode.

There has been greater reduction in growth of plants. Although, the multiplication of the nematode has been high in plants inoculated with both the pathogens but the size of the females has been smaller. This might in part be due to the fact that in plants infected with powdery mildews there is changed metabolism and physiology which might be favouring the egg laying capacity of nematode (Johnson et al. 1966). Of the different morphometric and allometric characters studied, the body length and body width were adversely affected. There has been no material effect on neck length, neck width, median

bulb length and median bulb width as a result of inoculation with powdery mildew (Table 22). Almost identical results have been observed on L. leucantha and C. sativus inoculated with S. fuliginea and M. incognita (Table 23 & 24). Although the multiplication of the nematode increases on the plants inoculated with powdery mildews but the size of females is reduced. This might be due to poor development of roots in nematode infected plants. Fungus component of the interaction has been shown to influence the population of nematode (Davis & Jenkins, 1963; Ketudat, 1969; Jacobsen et al., 1979; Ryder & Crittenden, 1965; Littrell and Johnson, 1969; Conroy et al., 1972 & Pandey,1984).

Since the results obtained above have been highly encouraging, it was considered desirable to study the effect of moisture and fertilizer stresses on both the components of the interaction. Highest development of powdery mildew on L. leucantha and C. sativus has been observed at the soil moisture of 30-40 percent. At extremely high and low soil moisture, the growth of plants has been poor and the plants die. The development of powdery mildew has been high at this moisture level. The optimum soil moisture, therefore, for the growth of L. leucantha and C. sativus and development of powdery mildew and root-knot, multiplication of nematode lie between 30-40 percent which is close to field capacity (Table 25 & 26).

At optimum soil moistures, the plant growth is normal. Which favours both root-knot development and powdery mildew. Probably the same explanation as given above for the interaction of both the pathogens under optimum soil moisture levels. However, at extremely high and low soil moistures the nematode development has been poor because in the former the soil pores are filled with water providing anerobic conditions and in the later water is practically not available to the nematode (Thames 1952 and Wallace 1956). Juveniles and egg masses undergo dessication despite the availability of some roots (Peacock, 1957). Moreover, plant roots also undergo anaerobiosis and are killed.

Although exact values of suction pressure have been studied but it appears that suction pressure corresponding to 30-40 percent soil moisture (which lies in the range of field capacity of the soils used in the present studies) is most conductive for nematode development (Wallace, 1959). The possibility of production of higher phenols in plants under moisture stress affecting both the pathogens adversely however cannot be ruled out (Fisher, 1979).

The intensity of powdery mildew has been high in those plants grown in soil fertilized with N alone as compared to those with K alone and with double dose of NK fertilizers (Table 29). The predisposing effect of excess of N and excess

of K inparting resistance against powdery mildew have been reported by several workers (Trelease and Trelease, 1928 and Mansson, 1955). However these results are at variance with those of Cole (1964, 1966) who reported excess of K favouring powdery mildew development. However, nematode development has not been found to be favoured with excess of nitrogen but K does favour the development of root knot as is indicated by high root knot index and higher values of morphometrics and allometric characters. Oteifa (1953) Shands & Crittenden (1957) Haque, et al. (1974) and Pant (1983) also observed the root knot development being favoured by high K fertilizers partly due to the fact that K ions are utilized by nematode development and egg production (Oteifa, 1952). Reduction in population of nematodes in excess of nitrogen is partly be due to release of ammonium ion which are toxic to nematode in soil (Oteifa, 1955 and Vasallo, 1967) and partly due to the ions forming some complex with certain soil components (Norton, 1978). These findings are in conformity with those of Bird (1960), Ismail & Saxena (1977) and Pant (1983).

Application of NK fertilizers together has a much more favourable effect on plant growth and nematode multiplication than N & K alone. The growth of inoculated plants increases with the increase in the dose of NK from sub-optimal to optimal

dose with a reduction in double dose (Table 29) which is obvious because higher doses of fertilizers are toxic not only to plants but also to pathogens (Oteifa, 1955; Vasallo, 1967 & Norton, 1978). Larger females have been observed in optimal dose of fertilizers.

Reduction in growth of L. leucantha and C. sativus as a result of inoculation with powdery mildew, nematode alone and together has been more when plants are grown in unautoclaved soil than in autoclaved soil (Table 33), which might be due to the presence of other soil microorganism and powdery mildew adversely affecting the growth of plants in addition to root-knot nematode (Upadhyay et al. 1972). On the other hand, the development of powdery mildew and root-knot nematode, nematode population and measurements of female have been high in plants grown in autoclaved soil as compared to unautoclaved soil (Table 34), which might be due to the fact that in autoclaved soil there has been less competition in amongst microorganism as compared to those in unautoclaved soil (Subramanian, 1964; Desai et al. 1972 & Alam et al., 1973). These results are thus in agreement with those of Singh (1981) and Pant (1983).

Studies dealing with the rhizosphere mycoflora of plants infected with nematode and powdery mildews show that there has been more fungi in the rhizosphere of those plants grown in

unautoclaved soil than autoclaved soil. Moreover rhizosphere of plants infected with both the pathogens harboured more fungi than with fungus nematode alone. When compared with the plants inoculated separately with two pathogens, the number of fungi in the rhizosphere has been more in those inoculated with nematode alone (Table 35). This is understandable as the root knot nematode galls have been reported to contain substances known for stimulating the growth of fungi and these substances are exudated in the rhizosphere fungi(Loewenberg et al., 1960).

The number of fungi being less in autoclaved soil could be in part due to the fact that a mycoflora has to develop a fresh and all the existing fungi have been killed before inoculation.

Throughout the studies, a straight line correlation has been obtained between body length and body width; body length and neck length; body length and median bulb length; body width and neck width and body width and median bulb width while determining the morphometrics of the female of the root knot nematode Meloidogyne incognita under different conditions (Fig. 15 to 19). These are in confirmity with the results of those of Pant (1983) and Hakim (1983).

Figure. 15. The relationship between body length and body width of females of root knot nematode Meloidogyne incognita when inoculated with nematode and fungus under-moisture, fertilizer stresses.

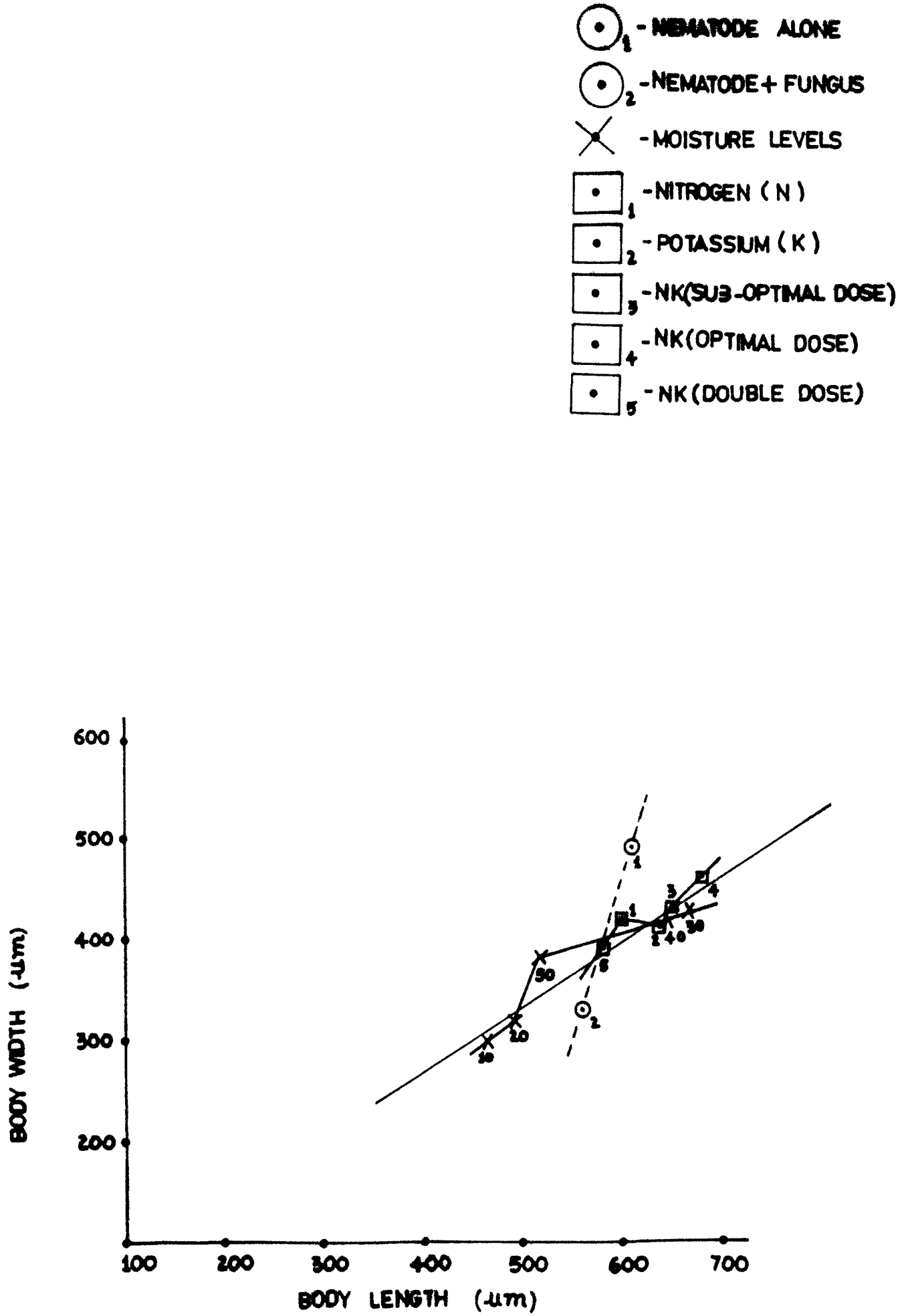

1 - NEMATODE ALONE
2 - NEMATODE + FUNGUS
- MOISTURE LEVELS
1 - NITROGEN (N)
2 - POTASSIUM (K)
3 - NK(SUB-OPTIMAL DOSE)
4 - NK(OPTIMAL DOSE)
5 - NK(DOUBLE DOSE)
BODY WIDTH (µm)
600
500
400
300
200
100
200
300
400
500
600
700
BODY LENGTH (µm)

FIG. 15

Fig. 16. The relationship between body length and neck length of females of root knot nematode Meloidogyne incognita when inoculated with nematode and fungus under-moisture, fertilizer stresses.

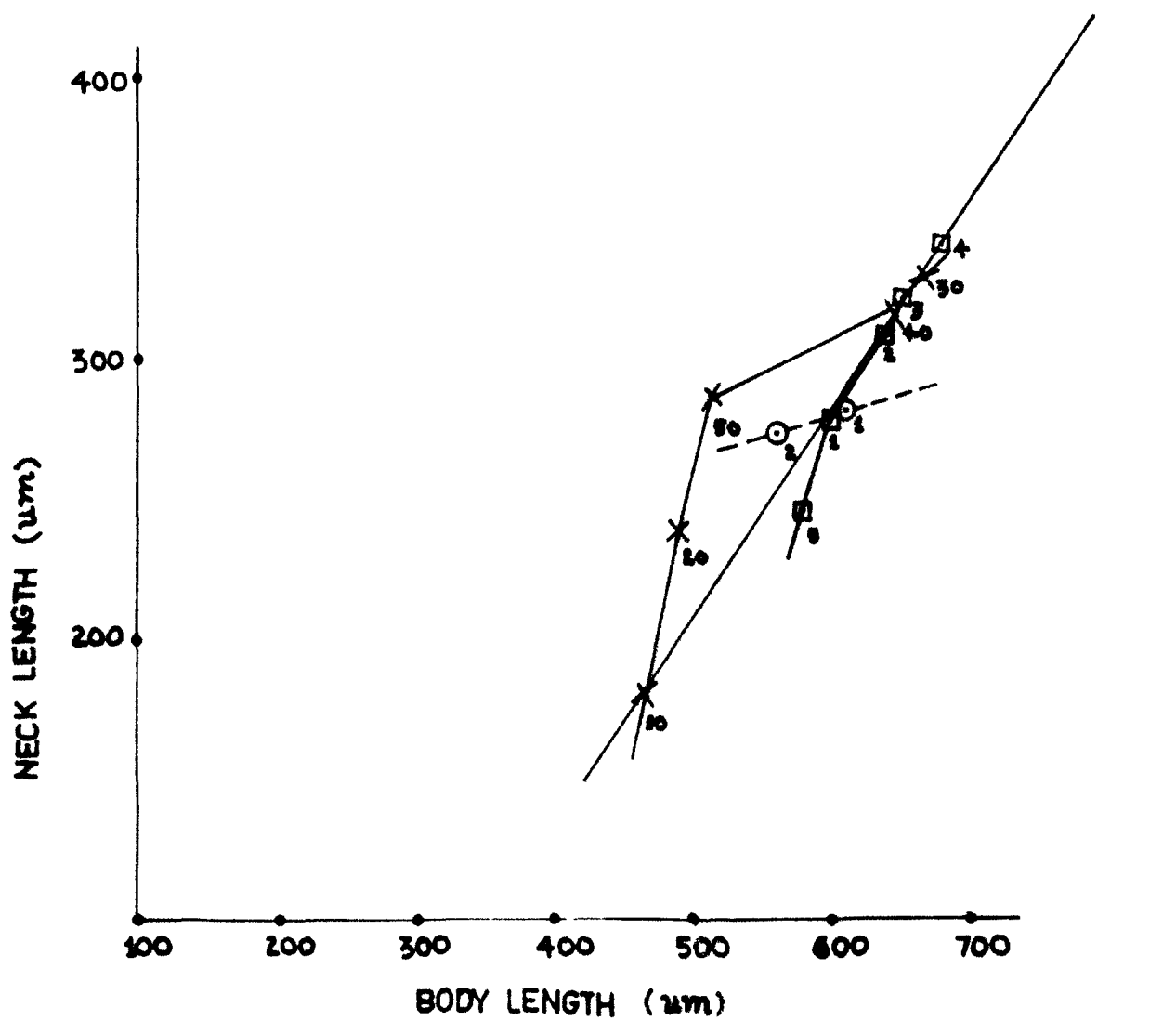

1 - NEMATODE ALONE
2 - NEMATODE + FUNGUS
- MOISTURE LEVEL
1 - NITROGEN (N)
2 - POTASSIUM (K)
3 - NK (SUB-OPTIMAL DOSE)
4 - NK (OPTIMAL DOSE)
5 - NK (DOUBLE DOSE)
NECK LENGTH (µm)
400
300
200
100
200
300
400
500
600
700
BODY LENGTH (µm)

FIG. 16

Fig. 17. The relationship between body length and median bulb length of females of root knot nematode Meloidogyne incognita when inoculated with nematode and fungus, under-moisture, fertilizer stresses.

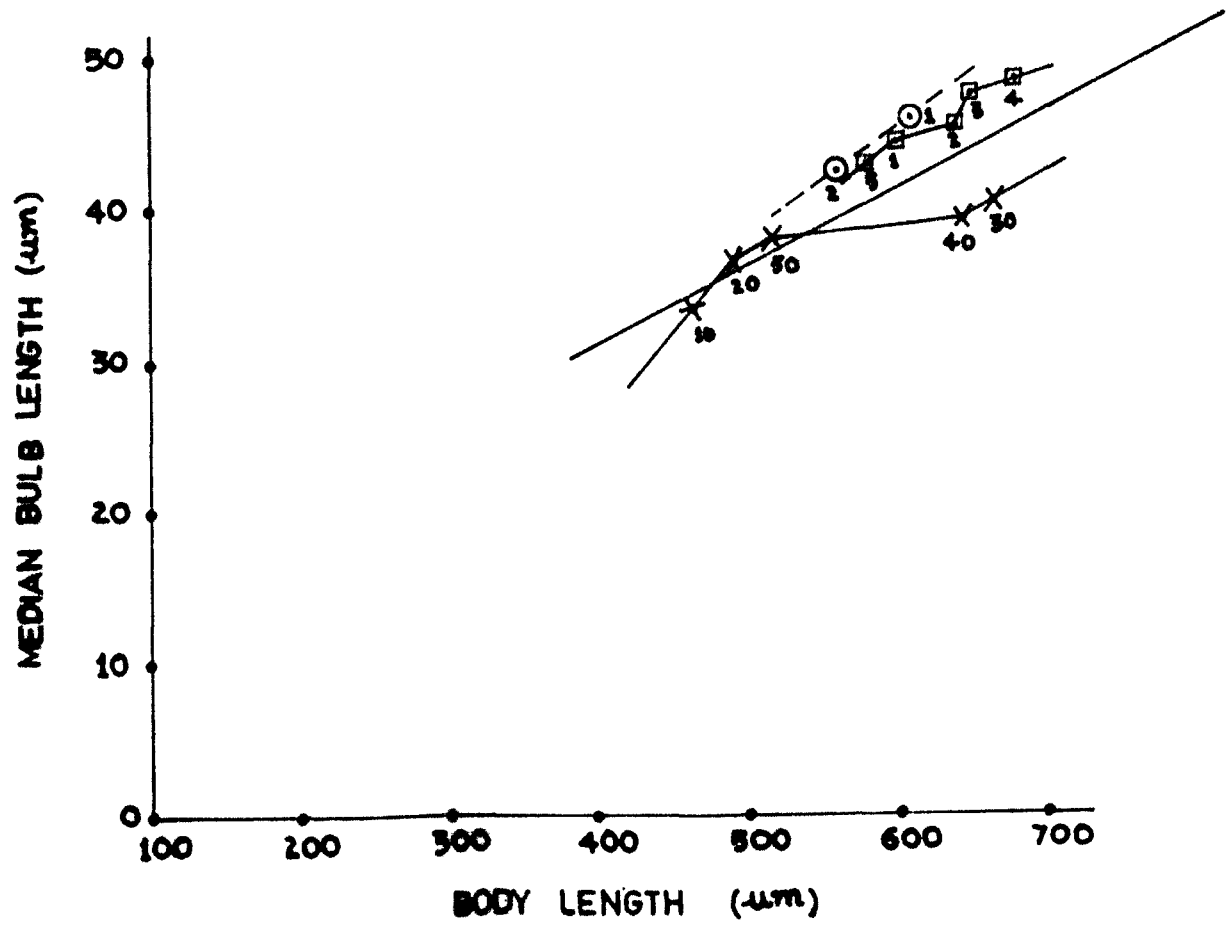
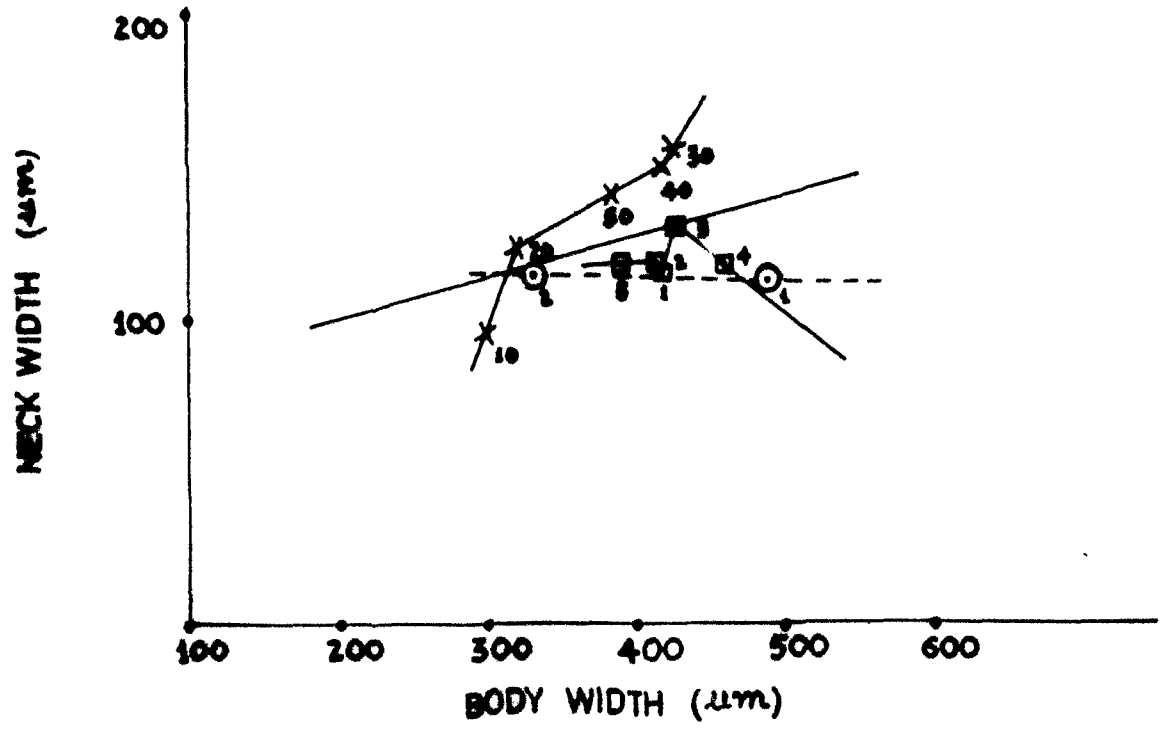

1 - NEMATODE ALONE
2 - NEMATODE + FUNGUS
- MOISTURE LEVEL
1 - NITROGEN (N)
2 - POTASSIUM (K)
3 - NK (SUB-OPTIMAL DOSE)
4 - NK (OPTIMAL DOSE)
5 - NK (DOUBLE DOSE)
MEDIAN BULB LENGTH (µm)
0
10
20
30
40
50
100
200
300
400
500
600
700
BODY LENGTH (µm)
10
20
30
40
50

FIG. 17

Fig. 18. The relationship between body width and neck width of females of root knot nematode Meloidogyne incognita when inoculated with nematode and fungus under-moisture, fertilizer stresses.



- NEMATODE ALONE
- NEMATODE+FUNGUS
- MOISTURE LEVEL
- NITROGEN (N)
- POTASSIUM (K)
- NK (SUB-OPTIMAL DOSE)
- NK (OPTIMAL DOSE)
- NK (DOUBLE DOSE)

FIG. 18

Fig. 19. The relationship between body width and median bulb width of females of root knot nematode Meloidogyne incognita when inoculated with nematode and fungus under-moisture, fertilizer stresses.

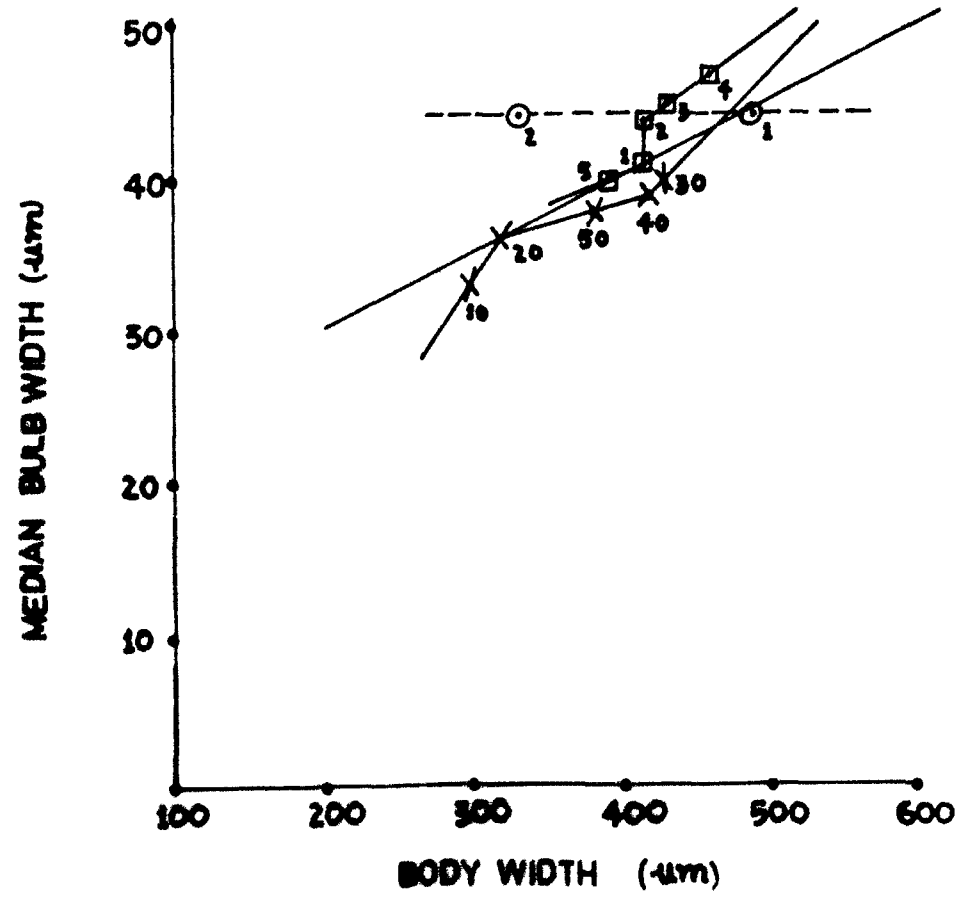

1 - NEMATODE ALONE
2 - NEMATODE + FUNGUS
- MOISTURE LEVEL
1 - NITROGEN (N)
2 - POTASSIUM (K)
3 - NK (SUB-OPTIMAL DOSE)
4 - NK (OPTIMAL DOSE)
5 - NK (DOUBLE DOSE)
MEDIAN BULB WIDTH (μm)
BODY WIDTH (μm)
50
40
30
20
10
100
200
300
400
500
600
10
20
30
40
50

FIG. 19

SUMMARY

During survey, the incidence and severity of powdery mildew has been studied on different members of the family compositae and Umbelliferae at different localities in Aligarh during different parts of the months. There has been two flushes of powdery mildew on composits from January to March and other from October to December while on Umbelliferous hosts there has been one flush from January to early May.

The powdery mildew of different members of compositae has been identified as Erysiphe cichoracearum based on conidial characters. However, on Umbelliferous plants E. heraclei caused the powdery mildew. Cleistothecia of E. heraclei were observed on the leaves of Daucus carota.

In host range studies Co. sulphunus, S. oleraceus and X. strumarium were susceptible to X. strumarium isolate of E. cichoracearum; D. variabilis, Z. elegans and H. annuus to both the isolates from H. annuus and D. variabilis. All the plants belonging to Umbelliferae were susceptible to E. heraclei except Ca. copticum. Amongst the varieties of composits tested, almost all of them have been found susceptible to highly susceptible to the two composit isolates of E. cichoracearum.

All the varieties of D. carota have been found highly susceptible to susceptible both in glass house and in field to the all isolates of E. heraclei.

The optimum temperature for the germination of conidia of E. cichoracearum ranged between 17-20°C, while that of E. heraclei 20 - 25°C. Highest germination of conidia of both E. cichoracearum and E. heraclei took place at 95 - 100 percent relative humidity but they failed to germinate in free water.

The relative humidity does not appear to exert much influence on the development of disease at optimum temperature but temperature appeared to a deciding factor as disease developed within 5 days at optimum temperature irrespective to relative humidity.

Of the different members of the fam. Compositae tested for the susceptibility of root-knot nematode Cl. officinalis was highly susceptible, D. variabilis and Cineraria spp were moderately susceptible however in Co. sulphulus, the larvae although penetrated but did not metamorphise in to mature females. Susceptible plants also favoured higher values of morphometrics of females.

The root-knot infected seedlings of D. variabilis were inoculated with E. cichoracearum and that of L. leucantha and C. sativus with S. fuliginea, there was greater reduction

in growth of plants inoculated with two pathogens. However, the morphometric values of the females of the nematode were low in plants inoculated with both the pathogen.

Of the different soil moisture levels tested (10, 20, 30, 40 & 50 percent) it was found that growth of plants of L. leucantha and C. sativus increased with increase in the moisture levels up to 40 percent followed by a decrease at 50 percent. The development of powdery mildew, however, increased with increase in the moisture levels. Highest root-knot development and multiplication of the nematode was observed at 30 - 40 percent moisture levels. The morphometrics of females showed low values in those moisture levels where the root-knot development was poor but higher values where the root-knot index was high.

The highest growth of seedlings of L. leucantha inoculated with root-knot nematode and powdery mildew and grown in soil fertilized with different doses of fertilizers (sub-optimal, optimal and double) was observed in plants supplied with optimal dose of fertilizers.

Studies on the effect of different stresses on plants (Lagenaria leucantha and Cucumis sativus) such as infection of roots with root-knot nematodes, soil moisture levels and N K fertilizers showed that when plants were under stress, the development of root-knot was adversely affected.

The effect on powdery mildew has been however variable. The severity of powdery mildew increased in plants inoculated with root-knot nematode. The powdery mildew development was also favoured in autoclaved soil. On the other hand, the severity of powdery mildew decreased when powdery mildew plants were subjected to high/low moisture stress or fertilizer stresses (without N and 2 N K).

The population of the nematode was high in K fertilizer alone followed by N. The highest population of nematode was observed in the optimal dose of N K fertilizers. The intensity of powdery mildew was highest in those plants grown in nitrogen alone.

Morphometric values were significantly higher in K fertilizer followed by N fertilizer. With different doses of N K fertilizers, morphometric characters were high in optimal dose as compared to double dose. When plants were inoculated with both powdery mildew and nematode, the morphometric values of females were significantly reduced as compared to those where inoculation was done with nematode alone.

Seedlings of L. leucantha and C. sativus were inoculated with root knot nematode M. incognita and grown in naturally infested soil and autoclaved soil. The growth of plants, popu-

lation of the nematode and measurements of female were high in autoclaved soil in comparison to unautoclaved soil. Thus the rhizosphere fungi, which present in unautoclaved soil adversely affected the growth of plant and nematode development.

The plants inoculated with the two pathogens harboured more rhizosphere fungi as compared to the fungus and nematode alone. The build up of rhizosphere mycoflora was also high in naturally infested soil as compared to autoclaved soil.

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*Original Not Seen.

Appendix - I

List of Abbreviations

Abstr	Abstract
Cm	Centimeter
C.V.	Coefficient of variation
CV.	Cutivar
et. al.	et alu (= and others)
Fig.	Figure
gm	gram
i.e.	Id est (= that is)
L.S.D.	Least significant difference
P, PP	Page; pages
µm	micron
viz	Videlicet (= namely)
S.D.	Standard deviation
Sp, Spp.	Species
X	Mean
/	Per
C	Coriandrum Spp.
Ch.	Chrysanthemum Spp.
Co	Cosmos Spp.
Ca	Carum Spp.
Cu	Cuminum Spp.
Cl	Calendula Spp.

Appendix - II

Cultivars of different Plants	Name of the Suppliers
Helianthus annuus	
Var. Miniature japanese	N. Cooper, Poona
" Sungold dwarf	N. Cooper, Poona
" Chrysanthemum flower mixed	N. Cooper, Poona
" Bronge hybrid	N. Cooper, Poona
Zinnia elegans	
Var. Persian carpet	N. Cooper, Poona
" Linearis orange	N. Cooper, Poona
" California Giant mixed	N. Cooper, Poona
" Lilliput mixed	N. Cooper, Poona
Dahlia variabilis	
Var. Large flower mixed	N. Cooper, Poona
" Unurins hybrid mixed	N. Cooper, Poona
" Super Giant mixed	N. Cooper, Poona
" Decorative mixed	N. Cooper, Poona
Daucus carota	
Var. Pusa kesar	N. Cooper, Poona
" Tender Sweet	N. Cooper, Poona
" Danvers half long	N. Cooper, Poona
" Nantes early half long	N. Cooper, Poona

contd....

Appendix-II (contd..)

Lagenaria leucantha	
Var. Doodhi long	Panjab Seeds, Aligarh
Benincasa hispida	Panjab Seeds, Aligarh
Calendula officinalis	N. Cooper, Poona
Chrysanthemum carinatum	N. Cooper, Poona
Cosmos Spp.	University Area Aligarh
Coccinia cordifolia	University fort, Aligarh
Cucumis sativus	Punjab Seeds Aligarh
Sonchus oleraceus	Botany Department Aligarh
Xanthium strumarium	University area Aligarh.